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STUDENTS' ASTRONOMICAL
LABORATORY

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THE ECLIPSES OF 1916.

WILLIAM F. RIGGE.

There will be five eclipses during the year 1916. The first three will be completely visible all over the United States, the fourth can be seen only in Australia and its adjacent waters, while the fifth, although the least in magnitude and confined to a small section of almost inaccessible ocean, is in many respects the most interesting eclipse that has occurred for a life time.

It is the purpose of this article to present some account of these eclipses.

THE LUNAR ECLIPSE OF JANUARY 20.

The first eclipse of the year will be a partial eclipse of the moon on the early morning of January 20. Figure 1 will tell us the particulars.

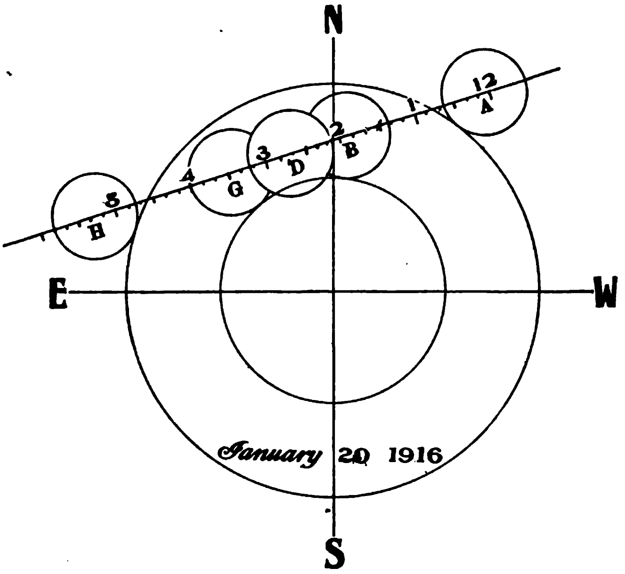

FIGURE 1.

PARTIAL ECLIPSE OF THE MOON JAN. 20, 1916

		Central Time
A	Moon enters Penumbra	12:05 A.M.
B	Moon enters Shadow	1:55
D	Middle of Eclipse	2:40
G	Moon leaves shadow	3:24
H	Moon leaves Penumbra	5:14

The largest circle in the diagram represents the earth's penumbra, and the next in size the earth's shadow, at the place where the moon crosses them. The letters N E S W are the points of the compass, which tell us to hold the diagram before us in such a way when looking at the moon, that the line NS points to the pole star. At midnight this line will be vertical with N on top. After that it will incline more and more to the right. We note that E is to the left in the sky, while on terrestrial maps it is towards the right. The long oblique line is the path of the moon, and gives the position of its center at intervals of ten minutes. The five equal small circles are five views of the moon at important moments. When its center is at A, at 12:05 A.M. central time, the Moon enters Penumbra. At B at 1:55, the Moon enters Shadow, and begins to be noticeably eclipsed, as if a piece had been cut off. At D at 2:40, we have the Middle of the Eclipse, when the Moon has entered deepest into the earth's shadow. Only fourteen percent of its diameter will then be eclipsed, so that it will not be worth the sacrifice of an hour's sleep to see it. At G at 3:24, the Moon leaves Shadow, and at A at 5:14 the Moon leaves Penumbra.

THE SOLAR ECLIPSE OF FEBRUARY 3.

The second eclipse will be an eclipse of the sun on the morning of February 3. Solar eclipses have been very rare of late in the United States, so that this one will be most welcome. Let not the appearance of Figure 2 deter the reader from gathering for his own locality all the

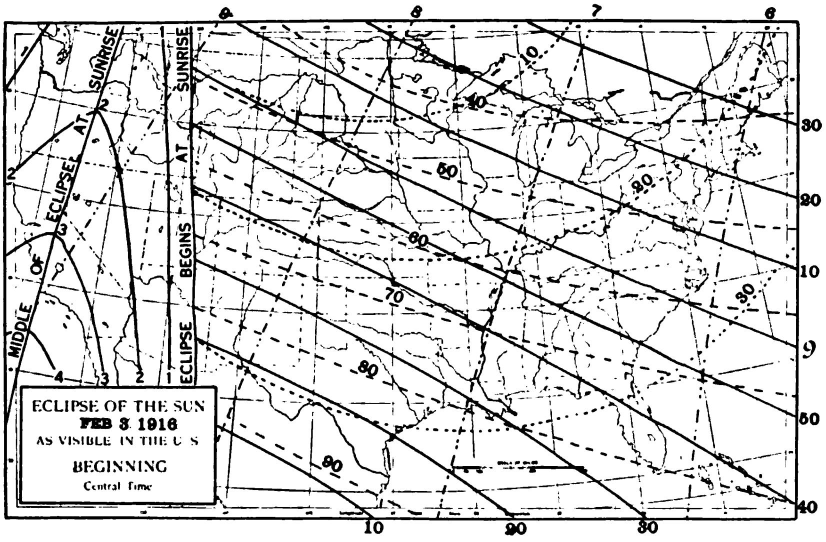

FIGURE 2.

information the map contains. With a little patience everything will be understood.

As the title indicates, Figure 2 refers to the beginning of the eclipse. The first thing of importance is the time. This is given at intervals of ten minutes and is shown by the full lines marked at the bottom and at the right of the map. The large 9 means 9 o'clock, central time, and the smaller numbers from 10 to 30 above and from 50 to 10 below the 9 indicate the minutes following and preceding 9 o'clock.

In looking for his own city, the reader may estimate its position in tenths of the distance of the lines on either side of it, and thus find the time to the nearest minute. He may practice the method by verifying 8:56 as the time when the eclipse begins at Omaha, and 9:07 as the time for Chicago.

The broken lines numbered 9, 8, 7, 6, on the top of the map, indicate the places at which sunrise occurs at 9, 8, 7, 6 o'clock central time. By remembering that each degree of longitude means four minutes of time, we can find the time of sunrise to the minute. This is 7:36 for Omaha and 7:05 for Chicago.

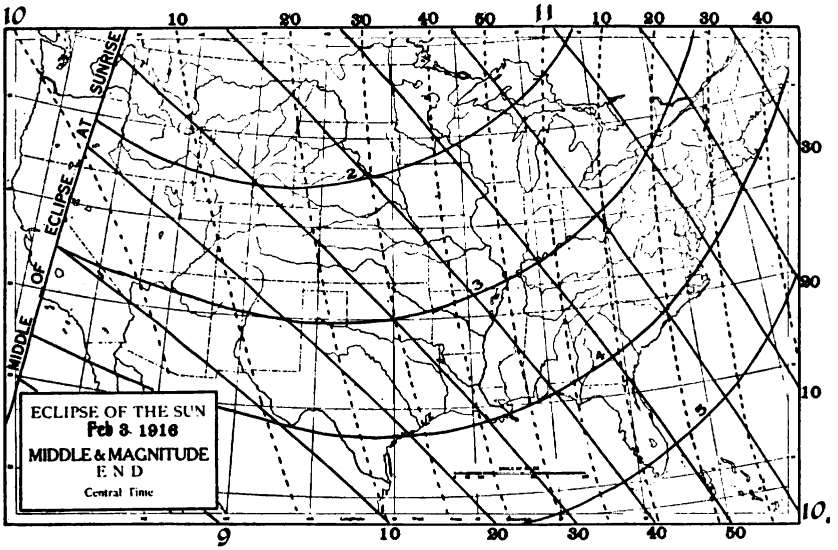

FIGURE 3.

Next to the time the most important fact to know is at what particular point the moon will first indent the sun. Let us imagine the lines NS and EW, on the diagram of the lunar eclipse in Figure 1, to be drawn on the sun as we look at it through a smoked glass, and then the whole circumference of the sun to be divided into 360 parts or degrees, as circles are always divided. Then the three dotted curves on the eclipse map, marked 10, 20, 30, will tell us that for places situated on these lines the eclipse will begin at a point 10, 20, 30 degrees west of the sun's south point. For all other places we measure their proportional distances from these curves and get the "position angle" to the nearest degree. Thus at Omaha the "point of first contact" has a position angle of S 16° W.

It will be necessary, however, as in the case of the lunar eclipse, to incline the line NS, this time to the left, until it points to the north star, because the point on the sun nearest this star is the north point. As it may be difficult or even practically impossible to do this with precision, the eclipse map gives another set of curves marked from 40 to 90, in which the position angle is counted from the sun's lowermost point towards the right. For Omaha this angle is 54 degrees.

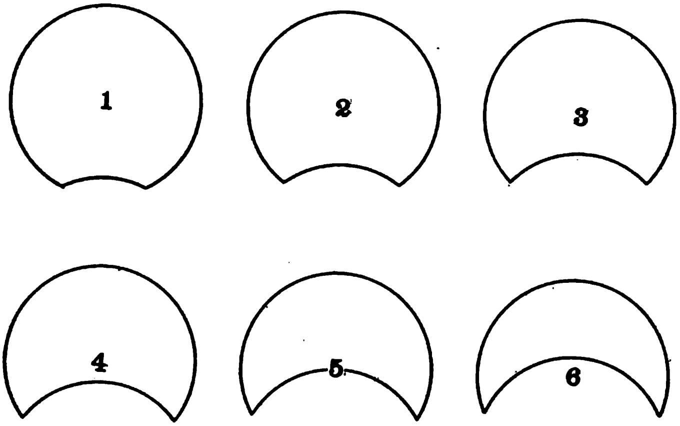

FIGURE 4.
APPEARANCE OF THE SUN AS VARIOUS TENTHS OF ITS DIAMETER ARE ECLIPSED.

Figure 3 will give us all the information we need in regard to the size of the eclipse, and the time of its middle and its end. The size or magnitude is indicated by the four full line curves marked 2, 3, 4, 5, which mean that for places on those lines the sun's diameter is eclipsed so many tenths. If we imagine a 0 after these numbers, we might say that they indicated the percentage of the obscuration. By measurement similar to that mentioned before, we see that at Omaha the magnitude of the eclipse is 23 percent.

In order to know what the sun will look like when 2, 3, 4, 5, tenths, or 20, 30, 40, 50 percent of its diameter are obscured, we turn to Figure 4 for the corresponding number. Intermediate ones, of course, we may estimate or draw. We can thus prepare a view of the eclipsed sun a long time in advance, and get it more accurate than we can observe it.

Coming back to Figure 3, we find that the time when the eclipse is greatest, or the time of the maximum obscuration, or that of the middle of the eclipse, is indicated by the numbers below the map and to its right. At Omaha this time is 9:41 or 9:42.

Finally, the dotted curves marked at the top show the time of the end of the eclipse, the time of "last contact". This is 10:34 for Omaha.

Our westernmost neighbors will not see the whole of the eclipse, because for them the eclipse will have already begun before the sun rises. This will be the case west of the line on Figure 2 marked "Eclipse begins at Sunrise". Another line marked "Middle of Eclipse at Sunrise" which is given on both maps, Figures 2 and 3, means that between the two lines mentioned the sun rises eclipsed to the extent indicated by the curves 1, 2, 3, 4 on Figure 2 which mean, as before, the tenths of obscuration, and that the eclipse will increase until it reaches the magnitude shown on Figure 3. West of the line "Middle of Eclipse at Sunrise" the sun rises eclipsed to the extent shown on Figure 2, but the eclipse will then be decreasing, its end occurring at the time indicated on Figure 3.

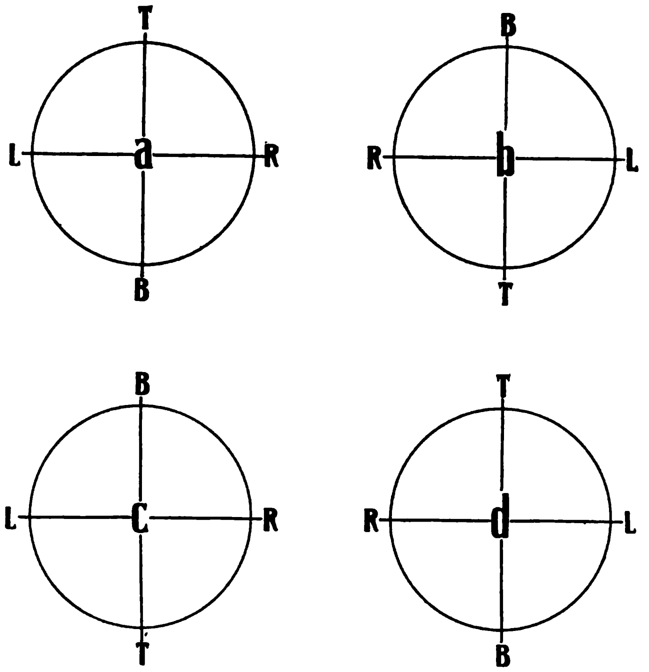

FIGURE 5.

In observing an eclipse of the sun, it is advisable to make use of a telescope of some sort, especially if we wish to note the exact moments of its beginning or of its end. The simplest kind of spyglass will do, if we know how to use it. A few hints in that direction may be of service.

If our telescope shows terrestrial objects as they appear to the unaided eye, that is, up-side-up and right-side-right, we will see the sun's cardinal points N S E W correctly. Replacing these by the more convenient points T, B, R, L, top, bottom, right, left, we see the sun as drawn in Figure 5a. If we remove the inner pair of lenses from a common spyglass, we convert it into an astronomical telescope and see the sun inverted as in Figure 5b.

It is much better to project the sun's image on a piece of stiff white paper, than to look at it directly. With the smoked glass, which must always be used when we look at the sun directly, beginners will experience the greatest difficulty in finding the sun at all in the sky with the telescope. If we hold the paper or a card beyond the eyepiece and point the telescope to the sun, we will see the sun's image on the card, and may give it any size we please by holding the card at the proper distance and focusing accordingly. No dark glass is then necessary, and we have the convenience of being able to use both our eyes and of showing the image to an admiring circle of friends, all of whom may look at it at the same time. Supporting the telescope properly, and fastening the card to a light wooden rod and the latter to the telescope, will make observing easy and interesting. The points on the sun will then appear as in Figure 5c if we are using a spyglass, and as in Figure 5d, when we have an astronomical telescope.

We may even dispense with a telescope altogether. An image of the sun is formed on our card by any small hole in a piece of pasteboard, or even by the chinks in our window shutters provided we do not allow the sunlight to pass through the pane. The image will then be like Figure 5c.

If we practice any one of the methods just mentioned sometime before the eclipse, we may do some real scientific observing when the proper time comes. Having drawn a circle on our card with two diameters at right angles and having lettered their extremities T, B, L, R, according to the method we are using, we may also mark our point of first contact. Holding the card in proper position when the eclipse is about to begin, and making the sun's image coincide with our circle, we may observe the time of first contact within a few seconds. A string with a weight hung in front of the card will insure our holding the line BT correctly vertical.

THE LUNAR ECLIPSE OF JULY 14-15.

The third eclipse of the year will be a lunar eclipse on the night of July 14-15. It may be said in a way to be the complement of the one of January 20 because then the magnitude was only fourteen percent, while in this eclipse it will be 80. Figure 6 will give the particulars.

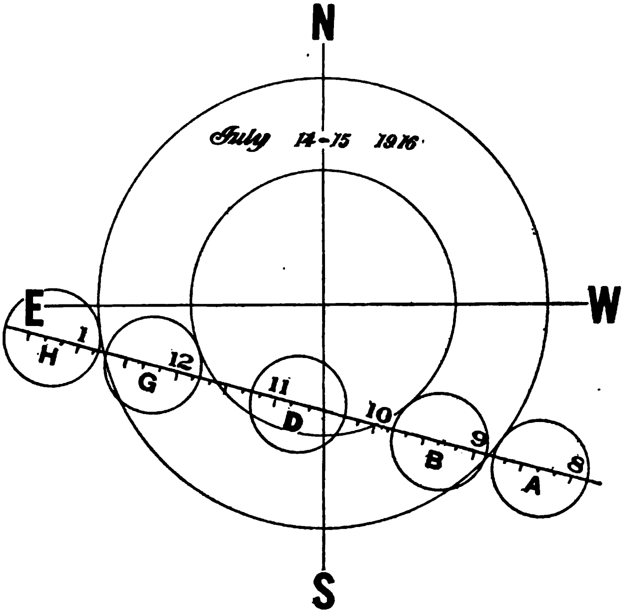

FIGURE 6.

PARTIAL ECLIPSE OF THE MOON JULY 14-15, 1916.

		Central Time
A	Moon enters Penumbra	8:18 P.M.
B	Moon enters Shadow	9:19
D	Middle of the Eclipse	10:46
G	Moon leaves Shadow	12:12 A.M.
H	Moon leaves Penumbra	1:14

The two largest circles represent as usual the earth's penumbra and shadow, and N E S W mark the cardinal points. The eclipse begins at 8:18 P. M. central time, when the Moon enters Penumbra with its center at the point A. At 9:19 the Moon enters Shadow. At 10:46 we have the Middle of the Eclipse. At 12:12 A.M. the Moon leaves Shadow and at 1:14 A. M. the Moon leaves penumbra.

The fourth eclipse of the year will be a solar eclipse on July 29, and will be visible, as said before, in Australia and its adjacent waters. As this eclipse is of no special interest to us in any way, we pass it over.

ECLIPSE OF THE CHRISTMAS MIDNIGHT SUN.*

The most remarkable eclipse in a certain way that can possibly occur, is the one that will come when we are busily preparing for Christmas, that is, when our clocks show 3 P.M. central time on Christmas eve. We in the United States will not even get a glimpse of it nor will any one in the whole of North and South America, nor in the wide extent of the Pacific Ocean. For us and for all these lands and seas the sun will be shining undimmed in its full splendor, as far as the weather and the season permit. But far away in the Antarctic Ocean, about half way between the Cape of Good Hope and the South Pole, over a limited tract of unfrequented waters, the sun will be eclipsed to such a tiny extent, a trifle over one percent, that it seems to be a downright waste of time, if not absolute folly, to mention it at all. But for the ships that may be there to see it, the eclipse will occur when some of them have midnight, Christmas midnight, while others have any hour or minute on Christmas eve from 9:41 P. M. to midnight, and a few have already for a few minutes after midnight begun Christmas day.

Look at Figure 7 for the explanation. Here we have the earth, the sunlit hemisphere, as it will appear to the sun at 2:40 P. M. central time. The sun will then be overhead in the centre of the figure, in latitude 23° 25′ south, and in longitude 130° west. The greater part of North America, and all except the extreme eastern part of South America, the whole Pacific Ocean and a part of Australia, will then have day. As the earth is turning eastward on its axis, that is, towards the right in the diagram, the sun will be setting all along the entire right half of the circle that is seen to bound the terrestrial globe in Figure 7, and rising all along its left half. The north pole is not visible, it is in the middle of its six months darkness. The south pole, however, is in full view, and as the date is but a few days after the winter solstice, the sun's rays shine 23 degrees and 25 minutes beyond the south pole, so that if the earth did not move in an orbit around the sun, but only turned on its axis, all the sunlit region about the south pole would have perpetual day.

The line N S crossing the earth is the central meridian, the only one of all the meridians on the earth to be projected into a straight line at the time mentioned, when our clocks show 2:40 P. M. central time on Christmas eve. Its longitude, as said before, is 130° west. All along that line it is noon. If we were to start at the very top of the figure near the letter N in latitude 66° 35′ north, the sun would be seen to just rise above the southern horizon at midday. For every degree of latitude that we go south on this central meridian, the sun is one degree higher at noon, and the day is getting longer. From a few minutes in latitude 66° 35′ north, it lengthens to 12 hours at the equator. where its length never changes all the year round. When we come to latitude 23° 25′ south, to the place in the exact centre of the diagram, the sun is directly overhead. As we proceed southward, the sun begins to sink towards the north. The day is all the time lengthening and becomes

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* Read at the California meeting of the American Astronomical Society, Berkeley, August 5, 1915.

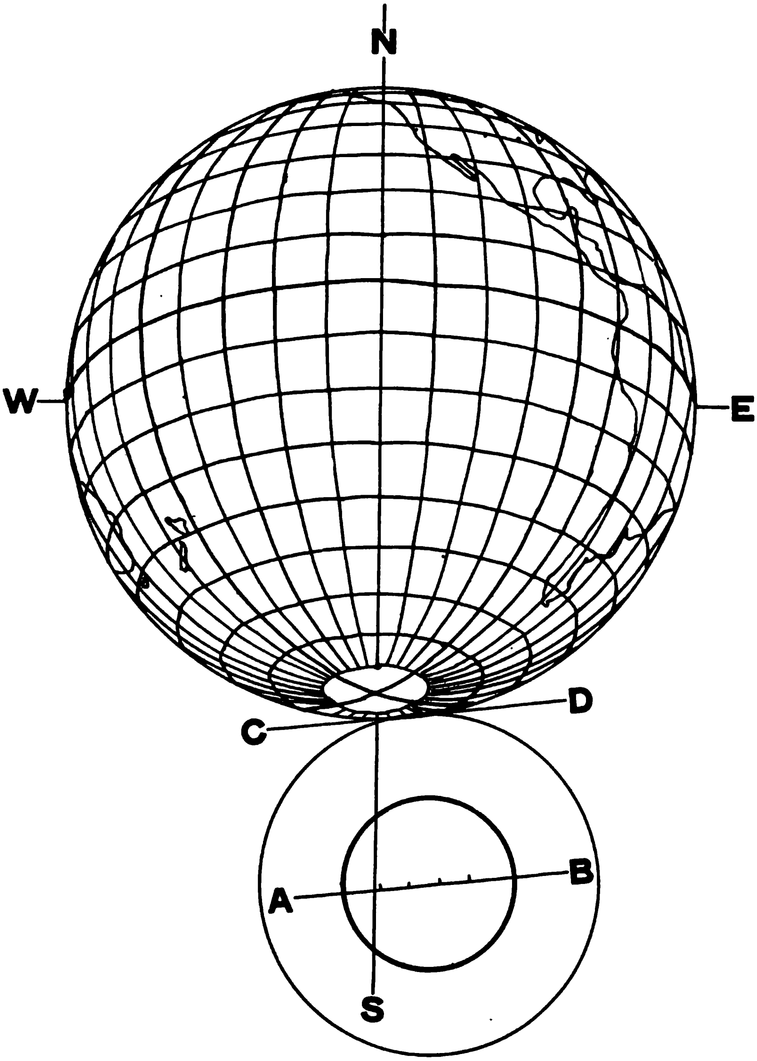

FIGURE 7.
SOLAR ECLIPSE OF DECEMBER 24-25, 1916.

equal to 24 hours as we reach the latitude 66° 35′ south, beyond which it lengthens rapidly until it becomes six months long at the pole.

As soon as we arrive at the south pole, there is no direction but north, since we cannot possibly go farther south than the south pole, and when we have reached it, any further motion must take us away from it, that is, carry us north. Hence as soon as we have passed the south pole, while we continue on our straight line or on our great circle, we are going north, the sun is now south of us, instead of north, as it was before, and noon has changed to midnight. The sun is visible until we come to 66° 35′ south latitude, the lowermost point on our diagram, when it will sink below the south horizon. All the way between this latitude and the pole, we can see the sun at midnight. As we leave this limit, that is proceed on our northward journey past the lowermost point on the diagram and enter the dark hemisphere, the sun begins to dip more and more below the south horizon at midnight. And all that has been said about our journey from 66° 35′ north latitude across the sunlight hemisphere towards 66° 35′ south latitude beyond the south pole, will be repeated in the same order if we exchange night and day, and north and south.

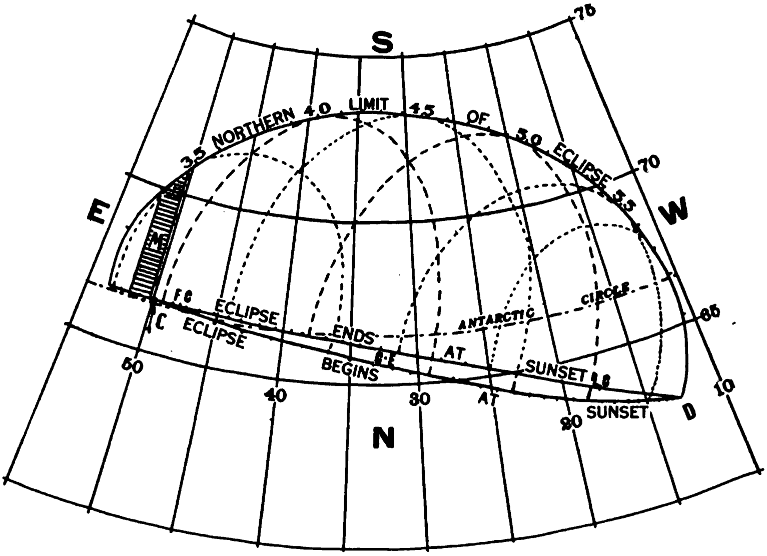

FIGURE 8.
MAP OF THE SOLAR ECLIPSE OF DEC. 24-25, 1916.

I must call attention to another fact, that is as soon as we passed the south pole, our meridian changed 180 degrees, from being 130 degrees west, it becomes 50 degrees east. We will need all these facts to understand the exceptional circumstances of the present eclipse.

The reader will also notice that only two meridians have been drawn across the south pole for the region within ten degrees of it. This was done to avoid confusion, since all the meridians meet at the poles. The two, or we may say, the four that are drawn, are first, the meridian of Greenwich, which is the one to the right and below, and quickly enters the dark hemisphere. The second one, the upper one to the right, is the 90th meridian, which we may trace through the middle of the Gulf of Mexico and the United States, and which is our own standard meridian and gives us central time, this being six hours slow of Greenwich. The next one on the diagram is the 180th meridian, on which all mariners change their date, dropping a day when going west and repeating it when going east. The last meridian drawn across the south pole, the lower one to the left, is the 90th east of Greenwich.

We may now turn our attention to the two circles below the terrestrial sphere on Figure 7. The smaller one is the moon. Its centre moves along the line AB, where its position is given for every ten minutes during the eclipse time, from 2:30 P. M. central time, on the first mark to the left, near the line N S, to 3:00 o'clock, on the last mark to the right.

The larger circle is the moon's penumbra, which is of great importance in every solar eclipse. To understand its nature and its action, I must ask the reader to try with me a very instructive experiment. Let us place a piece of white paper in direct sunlight and hold a small ball to the paper. We notice that the shadow is black and sharp and as large as the ball. As we separate the ball and paper, the shadow becomes more and more indistinct at the edge. The true shadow we call the umbra, and the indistinct part the penumbra. When we have separated our ball and paper so far that their distance apart is 114 times the size of the ball, the umbra has diminished to a point and the penumbra has grown to have a diameter twice as large as the ball. If our ball is as large as the moon on Figure 7, and is held at a distance of 114 times its diameter from the figure, its shadow or umbra will be the point on the line AB which is at the time 2:46, while the penumbra will be the outer and larger circle. We will not be able to see the umbra and penumbra on our paper, because the first is a point and the second is too faint, but they are really there, notwithstanding. We can actually see them or their effects very accurately if we put our eye in the place of the paper and look at the ball, taking the precaution to use a smoked glass. When our eye is exactly on the circumference or edge of the penumbra, we will see our ball apparently touching the sun. This astronomers call contact, first contact when the eclipse begins, last contact when it ends. As we move our eye along, or better, as our moon, the ball, moves across the sun, we will see the sun obscured more and more, until it is completely covered and we have a total eclipse.

Now as the moon's distance from the earth may vary about sixteen percent, the moon when far away appears smaller than usual and cannot cover the whole sun, whereas when near it appears larger and can more than cover the whole sun. In the first case, the point of the moon's shadow, the apex of the shadow cone, does not reach the earth; the sun appears as a ring of light about the black moon, and we have an annular or ring eclipse. In the second case the apex of the shadow would penetrate the earth if the latter were transparent, or which amounts to the same thing, the moon's shadow on the earth is of some size, and everyone that chances to be in it sees the sun totally eclipsed.

After this probably long, but necessary, preamble we are prepared to understand the exceptional conditions of the present eclipse. In an ordinary solar eclipse the path of the moon, AB on Figure 7, lies across some part of the earth, so that the places so situated may see a total or an annular solar eclipse. Every place inside the penumbra sees the sun partially eclipsed, the magnitude increasing almost in a direct ratio to nearness to its centre. Every place on the forward edge of the penumbra has first contact at the same moment, every place on its retreating side has last contact.

In some eclipses the central line does not fall on the earth at all, so that the eclipse is only a partial one everywhere. In the present eclipse the moon's path AB is so far off the earth that the penumbra does little more than graze the earth, covering it to the extent of only 0.008 of its radius, that is, only about 32 miles. This is the first most exceptional fact connected with the present eclipse, and has never happened before during the 33 years that the writer has studied eclipses.

The moment at which the penumbral circle overlaps the earth most is 2:46 P. M. central time. The diagram Figure 7 shows the penumbra in this position. As this is six minutes later than the time for which the terrestrial meridians were drawn, the earth has turned one and a half degrees more, so that the longitude of the central meridian at this time is 131½ instead of 130 degrees. The difference is hardly noticeable. If the penumbra had been drawn for the time 2:40, instead of 2:46, it would overlap the earth so little less that even a magnifying glass would not show the difference. In fact, the line CD which is parallel to AB and tangent to the penumbra, as well as the edges of the penumbra and earth, are all so close together that they practically coincide.

The second exceptional peculiarity of the present eclipse, is the fact of the penumbra's falling beyond the south pole, where on the diagram north and south exchange names, and east and west as well. For this reason, the penumbra moves *against* the diurnal motion of the earth and therefore shortens the duration of the eclipse, whereas if it were placed higher up on the diagram it would move *with* the earth, as it generally does, and lengthen the time of the eclipse.

Thirdly, the line CD, the "Northern Limit of the Eclipse," enters upon the earth at a point to the left of the line NS, so that CD crosses NS on the earth's disk. As the local time on this part of the line NS is midnight, there is in fact an eclipse of the midnight sun. That the line CD does really enter the terrestrial sphere at the place mentioned, as well as all the other data that are necessary for the construction of the eclipse map, could never be known by even a microscopic examination of Figure 7. Recourse had to be had to rigorous and lengthy calculations, which alone could ferret out the desired knowledge. Deriving the necessary data from a diagram like Figure 7 is always a very easy and expeditious method, when the penumbra crosses the earth somewhat centrally, and was the one used for the eclipse of February 3 given at the beginning of this article. Here, however, the graphic method fails utterly,—another peculiarity of the present eclipse which specialists will appreciate.

Fourthly and lastly, perhaps the most exceptional peculiarity of the present eclipse is the fact of its occurring for most places within the eclipse region on Christmas eve, for some at Christmas midnight. and for some others on Christmas morn.

In order to bring this rather lengthy article to a close, let us look at Figure 8, the eclipse map, and see what wonderful facts calculation has elicited from that minute portion of Figure 7, where the moon's penumbra passes across the earth's disk.

The first thing we notice on the map, Figure 8, is that south is on top and west to the right, in other words, that the map has been apparently reversed. This was done on purpose in order to facilitate comparisons of Figures 7 and 8. The numbers 50, 40, 30, 20, 10 below, mean the degrees of east longitude, and 75, 70, 65 to the right the degrees of south latitude. The broken parallel of latitude is the Antarctic Circle.

The point C is where the line CD of Figure 7 enters the earth, and the point D where it leaves it. The half ellipse marked "Northern Limit of Eclipse" is the projection of the straight line CD of Figure 7 on the spherical earth, distorted partly by its rotation. The point FC on Figure 8 is the place of "First Contact", the very first place on earth to see the eclipse begin, and LC that of "Last Contact", the very last to see it end. The point GE is the place of the "Greatest Eclipse", where one percent of the sun's diameter is covered by the moon. The dotted curves tangent to the "Northern Limit" at the numbers 35, 40 and so on, are successive projections of the circular rim of the moon's penumbra at the corresponding minutes after 2 P. M. central time. The last one to the right, however, is the one for 2:59. The eclipse begins at those minutes all along the western portion of the curve from the number on the "Northern Limit" line to the curve "Eclipse begins at Sunset", and ends along the eastern portion from this same number to the curve "Eclipse ends at Sunset". The penumbra moves westward, as was said before, instead of eastward as in all other eclipses.

The shaded portion near the letter M shows the region where the Christmas midnight sun will be eclipsed. To the right of this region the eclipse occurs between 9:41 P.M. and midnight, local time, on Christmas eve; to the left of it after midnight on Christmas morn. The longest duration of the eclipse at any one place is 17 minutes. For the whole region, or as astronomers say, for the earth generally, it is 28 minutes, from the moment of First Contact at 2:32 P. M., central time, when the eclipse begins at the point FC, to 3:00, the moment of Last Contact, when it ends at the point LC.

Creighton University Observatory,
Omaha, Nebr.

THE GIANT SUN CANOPUS.

CHARLES NEVERS HOLMES.

Most of us have never seen the great southern sun Canopus, about which many of us know far less than we should; and a translation of a part of an article by the famous French astronomer, M. Camille Flammarion, which appeared in *L'Astronomie*, January, 1915, presents many interesting and instructive facts about "Le Soleil Géant Canopus,"

"The barbaric follies of our wretched terrestrial human nature should not cloud from our minds the splendors of celestial contemplation. If our planet should be inhabited during some ten millions of years, according to astronomical and geographical agreements, and if humanity is not yet older than four hundred thousands of years at the most, she has not yet passed her fourth year relative to the age of normal life; and her unconscious cruelties are to be explained as those of children. She will go through evolutions in the future.

"We are able to estimate within two or three thousands the number of thinking creatures, comparatively well-educated, and intellectually alive. This number would represent about five millions of intelligent, wise men upon the terrestrial globe: this is probably exaggerated; but let us admit it.

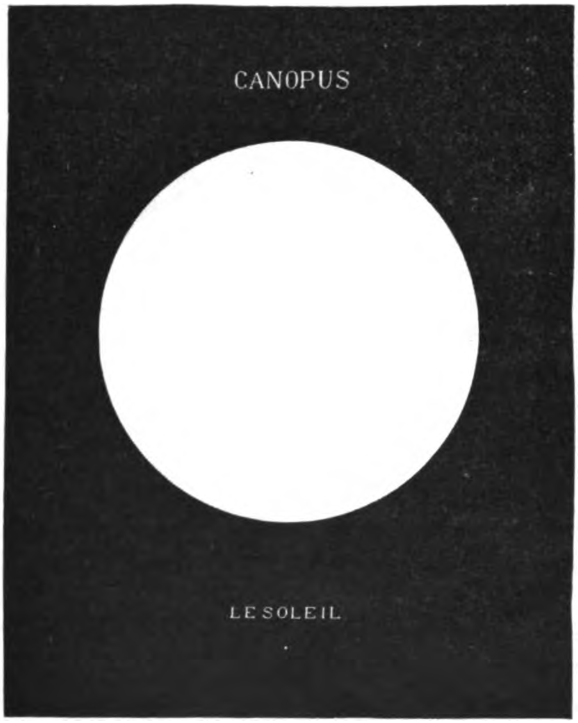

FIG. 1. COMPARATIVE SIZE OF CANOPUS AND THE SUN (LE SOLEIL).

"It is with this class of minds that we speak here. They have grown up more quickly than the mass, they have gone through evolutions, *they think*.

"Of all sciences, Astronomy is, without comparison with any other, that which develops most our conceptions and which frees us most from the gross attachments of matter. It is beautiful, it is consoling, to see in the observatories of the whole world patient searchers penetrating more and more deeply the secrets of the Universe and discovering gradually the mysteries hidden in the majesty of theories.

"Our readers know the most stupendous of all the suns of the infinite visited by our telescopes, that grand, that almost fabulous CANOPUS, the star Alpha of the constellation of The Ship, concerning which we have often spoken in these pages, for more than a third of a century. According to the closest estimate, his surface surpasses that of the sun some 18,000 times, his diameter some 134 times, and his volume some 2,420,000 times that of our furnace.

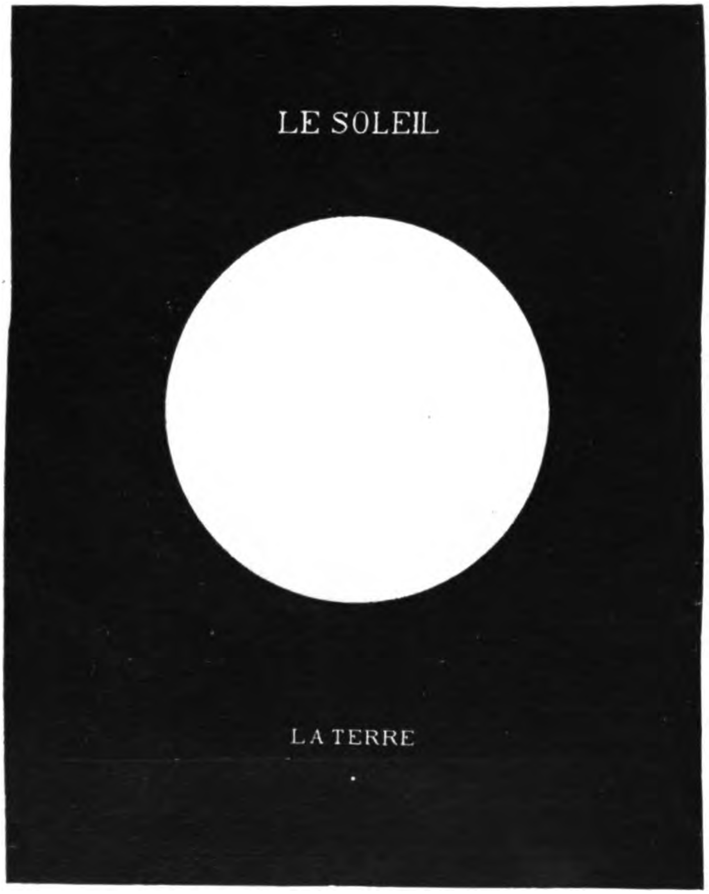

FIG. 2. COMPARATIVE SIZE OF THE SUN (LE SOLEIL) AND THE EARTH (LA TERRE)

"Numbers do not present to the mind striking pictures comparable with those of the drawing. That is why it has seemed advantageous to me to draw for our readers two figures to represent these numbers. In the first, the sun being represented by a disk of a half-millimeter,* Canopus with a diameter 134 times greater; in the second, the sun is in his turn drawn in his exact proportion with the earth, that is to say, with a diameter 109 times larger than that of our Planet, represented by a disk of a half-millimeter. These drawings, very simple, are prodigious and eloquent.

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* In reproducing these pictures our engravers unfortunately have reduced them to smaller scales. The relative sizes are however correctly given. [EDITOR POPULAR ASTRONOMY.]

"The most precise researches indicate that this star of first magnitude, nevertheless for us inferior in brilliancy to Sirius (— 1.0, Sirius being —1.6) is incomparably more remote from us than Sirius, his most probable parallax being about 0″.007 and that of Sirius 0″.37. This gigantic sun would be 49,700 times brighter than our pale furnace. There would result from this, as we have just stated it; for his surface 18,000 times that of the sun, for his diameter 134 times, and for his volume 2,420,000 times that of the sun.

"An English astronomer, M. O. R. Walkey, has just calculated, according to a mass of very curious probabilities, that this truly formidable star can be the center of our sidereal universe. Its mass would surpass by a million and a half times that of our furnace."

Hotel Nottingham,
Boston, Mass.

THE GRAPHICAL COMPUTATION OF TRANSIT FACTORS.

THORNTON C. FRY.

In the use of the transit instrument, Mayer's equation

$$\Delta T + Aa + Bb + Cc = \alpha - T$$

is involved. The coefficients, A, B, and C, of this equation are functions of both the latitude, ϕ, of the place of observation and the declination, δ, of the star observed. They are given by the equations

$$A = \sin(\phi - \delta) \sec \delta,$$
$$B = \cos(\phi - \delta) \sec \delta,$$
$$C = \sec \delta.$$

For work at a fixed observatory these coefficients may conveniently be tabulated, as they then depend on a single argument, δ. But when observations are to be taken at various places, the tables become long and their use laborious, owing to the double interpolation involved. If, as frequently happens, more than two places of decimals is not required, the following graphical tabulation may be used to advantage. The writer makes no pretence to originality of method. He believes, however, that the general theory * has not heretofore been recognized as applicable to the above equations.

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* For the general theory, see D'Ocagne, "Traité de Nomographie," Chapitre III.

For any given value of ϕ, the following construction may be carried out: Let a scale of values of the declination δ be constructed in any convenient manner along a line *CD*, Figure 1. Further, let a parallel *AB* be drawn, and an arbitrary point *P* chosen. Lines may now be drawn joining *P* with various points δ_1, δ_2, δ_3, ..., on the scale *CD*. By noting the intersections of these lines with *AB* and marking them with the corresponding values, A_1, A_2, A_3, ..., of *A*, a second scale is formed. If the position of *P* is changed a different chart is obtained.

These facts may be restated as follows: If ϕ be given a fixed value it is possible to choose scales *AB* and *CD* so that all lines joining corresponding values of *A* and δ pass through a common point, *P*. Moreover, this choice can be made in a great variety of ways.

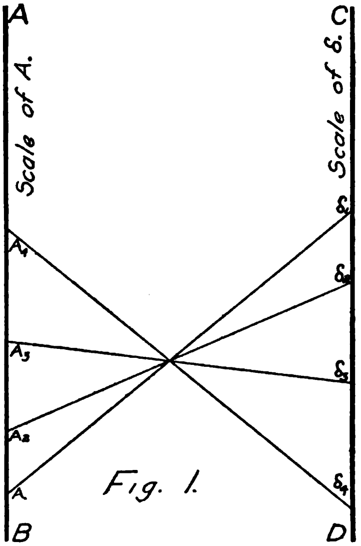

Fig. 1.

For each new value given ϕ a new chart may be constructed, but to construct many such charts is not feasible. The variety of charts possible for any one value of ϕ suggests the question: Is it possible so to choose a pair of scales *AB* and *CD*, that, for each fixed value of ϕ which may subsequently be assumed, lines joining corresponding values of δ and *A* on this chosen pair of scales will pass through a common point? The advantage of such an arrangement is obvious. The scales *AB* and *CD* being constructed once for all, it is only necessary to indicate the position of the point *P* corresponding to each value of ϕ in order that the single chart may be of service at various stations, that is, for various values of ϕ.

To secure the desired result is possible in only one way. The scale *CD* must be so numbered that the distance of any number δ from the zero of the scale shall be equal to the tangent of δ. The scale *AB* must be uniform. The points *P* corresponding to various values of ϕ then arrange themselves upon a smooth curve.*

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* In a very special case the curve is a parabola. Generally it is a hyperbola, whose transverse axis joins the zero points of *AB* and *CD*; whose vertex is $\frac{3}{8}$ the distance from *AB* to *CD*, and which passes through the points $+1$ and -1 on *AB*. These facts may be proved by the use of "line coördinates." See D'Ocagne, loc. cit.

A proof may also be effected *a posteriori* by setting up the equation of a line passing through the point *P* and proving that it intersects *AB* and *CD* in correspondingly numbered points.

The chart shown in Figure 2 was constructed in this manner. The actual labor is as follows: The scales AB and CD are first divided as explained above. Then pairs of values of δ and A are found for each desired value of ϕ.*

Each pair determines a line, and the intersection of two such lines is P. Finally each P is marked with the value of ϕ corresponding to it, and all are joined by a smooth curve. The construction for A is then complete.

To obtain a chart of the values of B a new scale is constructed along the hyperbola already drawn, with values of $\underline{\phi}$ given by the equation

$$\underline{\phi} = \phi + 90^\circ \quad \text{or} \quad \phi = \underline{\phi} - 90^\circ.$$

For readings on this scale

$$A = \sin(\phi - \delta)\sec\delta = -\cos(\underline{\phi} - \delta)\sec\delta.$$

the negative of which is the value of B corresponding to $\underline{\phi}$. For convenience a set of negatives of the numbers on the A-scale are arranged under the heading $\underline{B}$, so that B may be read directly. These numbers, and those corresponding to $\underline{\phi}$, are underlined† to avoid confusion.

C is a function of δ only, and to give a graphical representation of C requires only that each value of C be written directly opposite the δ to which it corresponds.‡

The use of the drawing may best be illustrated by an example. Find A, B and C if $\phi = 45^\circ$, $\delta = 37^\circ$. A black thread is first tightly drawn connecting $\phi = 45^\circ$ and $\delta = 37^\circ$. A is read off as $+0.18$.

The thread is then moved to join $\underline{\phi} = 45^\circ$, $\delta = 37^\circ$, and $\underline{B}$ read off as $+1.24$. For this purpose the underlined figures are used for both ϕ and B.

C is read directly opposite δ as $+1.25$.

Computation gives: $A = +0.174$, $B = +1.240$, $C = +1.252$. It will be found on trial with an accurately constructed drawing of moderate size, say 8″ x 10″, that results of such accuracy are to be expected.

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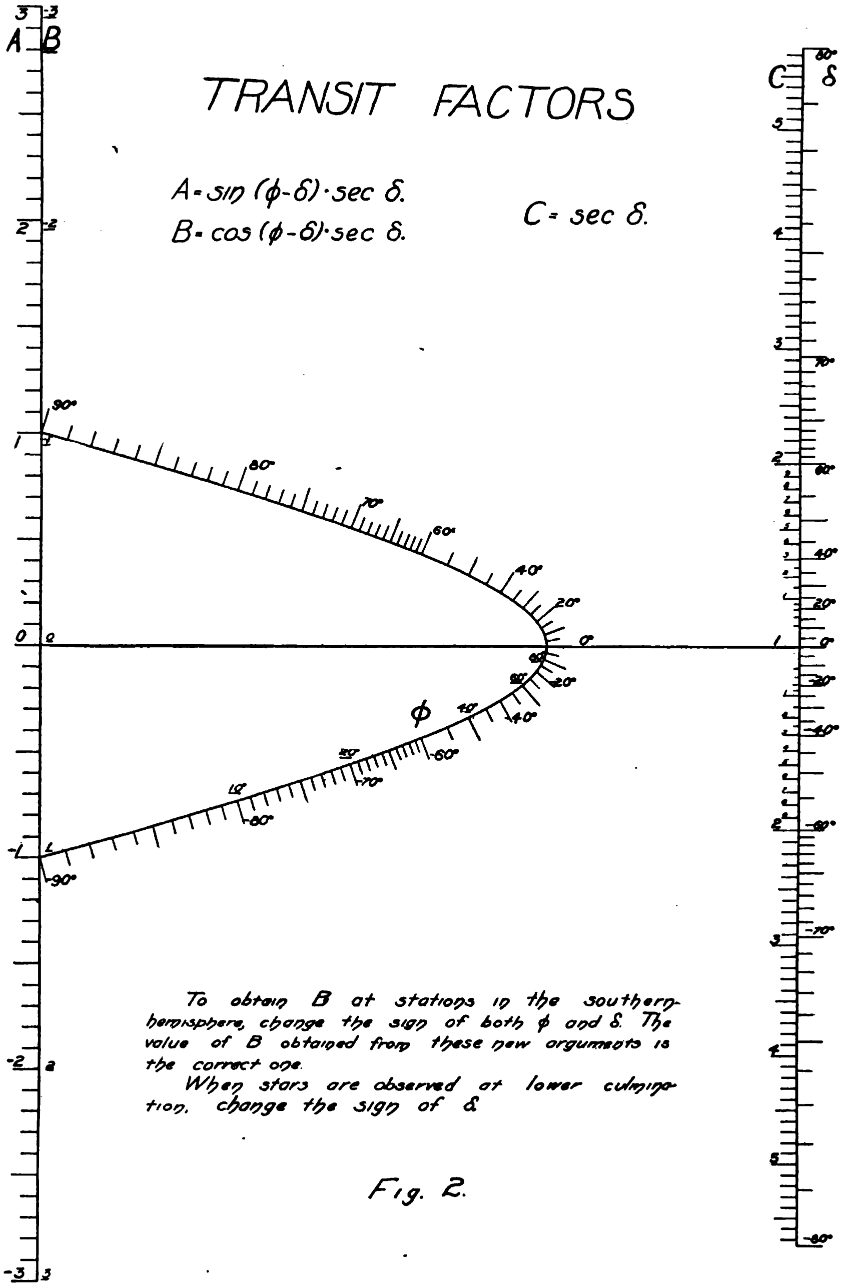
* In practice it is well to note that, if $A = 0$, $\delta = \phi$, and if $\delta = 0$, $A = \sin\phi$. When the point of intersection of the lines determined by these pairs may be easily located, they should be used. It is always advisable to compute a third pair of values to check the accuracy of the work.

† In practice it is better to use ink of a different color.

‡ This is most easily accomplished by noting that the height from the zero point to any value s of $\sec\delta$ is given by

$$h = \tan\delta = \sqrt{\sec^2\delta - 1} = \sqrt{s^2 - 1}.$$

Thus, the height of the number 2 is $\sqrt{3}$.



TRANSIT FACTORS

$A = \sin(\phi - \delta) \cdot \sec \delta.$

$B = \cos(\phi - \delta) \cdot \sec \delta.$

$C = \sec \delta.$

To obtain B at stations in the southern hemisphere, change the sign of both ϕ and δ. The value of B obtained from these new arguments is the correct one.

When stars are observed at lower culmination, change the sign of δ.

Fig. 2.

It must not be inferred that, because the scale interval between successive values of ϕ and δ at places is small, accuracy is impaired. Quite the converse is true. For, although it is impossible to distinguish accurately between 37° and 37° 15′, this very fact is only a graphical indication that, so far as values of A and B are concerned, slight variations in latitude are inconsequential when the latitude is not far from 37°. In the interest of accuracy it is important that the A, B and C scales may be read with equal ease at all points. A glance at Figure 2 will show that this condition is fortunately satisfied.

To find the value of B for observations taken at stations in the southern hemisphere, it is necessary to change the sign of both ϕ and δ. The reader can easily verify that this leaves B unchanged. This change is rendered necessary by the fact that negative values of ϕ occur on an infinite branch of the hyperbola, and cannot therefore be included in the chart.

To apply the chart to stars at lower culmination, it is only necessary to use $-\delta$ in place of $+\delta$. For such observations the sign of C is reversed according to the usual rule.

The following values of A computed from the chart of Figure 2 indicate the accuracy of the method:

δ	ϕ	A (from chart)	A (computed)	Error
75°	45°	−1.94	−1.932	+0.008
−20	45	+0.96	+0.964	+0.004
−10	60	+0.96	+0.954	−0.006
74	−50	−3.01	−3.008	+0.002
60	−10	−1.88	−1.879	+0.001
37	45	+0.18	+0.174	−0.006

University of Wisconsin,
October, 1915.

THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

PREFACE AND INTRODUCTION.

A perusal of the various histories and treatises on astronomy, in the quest for information on the subject of this research, showed most clearly that there was still opportunity for investigation, and that the question of the identity of the first observer of the solar spots was by no means settled. It was with the intention of ascertaining just how much could be learned that I entered upon this task. It has proved longer than was anticipated, but it is believed that the subject is of sufficient interest to warrant translating and presenting in English the early publications and letters, from which sources the information is to be obtained.

It is now more than three hundred years since the first telescopic observations of the spots were made, and during this interval many of the original manuscripts and letters, which might have yielded valuable information on questionable points, must doubtless have become lost. Consequently a reasonable skepticism toward any attempt to fix the discoverer of the solar spots is to be expected. In view of this, the only attempt that can be considered advisable is to present such facts and evidence as are in our possession at the present time, and to draw such conclusions from them as seem justified.

It is well known that spots were seen on the sun long before the invention of the telescope. In this paper no attempt will be made to discuss these pre-telescopic observations; the discussion will be confined entirely to the earliest observations with the telescope.

The principal memoirs and writings on the subject, which may be consulted with profit, and to which frequent reference will be made, are the following:

Notices Biographique, Galileo. Oeuvres de Francois Arago. Tome III, pp. 270-282. Paris, 1855.

Réflexions sur les Objections soulevées par Arago contre la priorité de Galilée pour la double découverte des taches solaires noires, et de la rotation uniform du globe du Soleil. Par Jean Plana. Memorie della Reale Accademia delle Scienze di Torino. Serie II. Tomo XX, pp. 151-187. Torino, 1863.

Sulla Priorita della Scoperta e della Osservatione delle Macchie Solari. Miscellanea Galiliana Inidita. Antonio Favaro. Memorie del Reale Istituto Veneto de Scienze, Lettere ed Arti. Volume XXII, pp. 729-783. Venezia, 1882,

Christoph Scheiner als Mathematiker, Physiker und Astronom. Anton von Braunmühl. Bayerische Bibliothek. Band 24, Bamberg 1891.

Der Magister Johann Fabricius und die Sonnenflecken, nebst einem excurse über David Fabricius. Eine Studie von Gerhard Berthold. Leipzig, 1894.

P. Christoph Scheiner, S. J. und seine Sonnenbeobachtungen, P. Joh. Schreiber, S. J. Natur und Offenbarung. Band 48. Münster, 1902.

L' 'Unicuique Suum' nella Scoperta delle Macchie Solari. Per. P. Bellino Carrara, S. J. Memorie della Pontificia Accademia Romana del Nuovi Lincei. Volume XXIII, pp. 191-287. Volume XXIV, pp. 47-127. Roma, 1905-6.

Mention should also be made of the magnificent *Edizione Nazionale delle Opere di Galileo Galilei,* in twenty volumes, published at Florence under the auspices of His Majesty the King of Italy during the years 1890-1909. This monumental work, which has been prepared and edited chiefly through the labors of Professor Antonio Favaro, is an almost inexhaustible storehouse of information concerning the writings and life of Galileo and his contemporaries.

Throughout the following pages, in the translations of the quotations from the cited references, the object has been to give a literal translation that would express as closely as possible the meaning of the original, rather than to attempt a free translation in more elegant English with the consequent sacrifice in accuracy.

The imperfections in what follows would have been many more but for the assistance of kind friends. I wish to express my most sincere appreciation and thanks to those who have given such generous assistance with the numerous translations, in particular to Dr. H. L. Crosby of the University of Pennsylvania, and to Drs. Herbert D. Austin and Percival B. Fay of the University of Michigan.

In order better to understand the difficulties encountered by the scientific investigator at the beginning of the seventeenth century, and the events which will be described later on, it will be advisable, before discussing the discovery of the solar spots, to outline briefly the condition of astronomical thought in Europe at that time, and to trace the course of events which had given rise to that condition.

The two chief problems of astronomy which had occupied men's minds since the early days when astronomy was thought of at all were the shape of the earth and the motions of the heavenly bodies, in particular the motions of the planets. The ideas extant in Europe had been derived in the main from the ancient Greek writers. Of these, the two whose writings maintained the greatest influence were unquestionably Aristotle and Ptolemy. The great influence of Aristotle and the veneration in which his writings were held, is easy to understand when we realize that he was the first, and for many years the only one to attempt to systematize the whole amount of knowledge accessible to mankind. The Aristotelean system of the World distinguished sharply between the heavens, the region of unchangeable order and perfection, in which the incorruptible heavenly bodies moved with perfect circular motions; and the earth, the region of instability and change placed immovable at the center of the universe. Unfortunately the Greek astronomy of Aristotle's time was, as it were, crystallized in his writings, which thus became somewhat encyclopedic in character, and his great authority was invoked centuries afterward by comparatively unintelligent or ignorant disciples in support of doctrines plausible enough in his time, but which subsequent research was showing to be untenable.

As Aristotle had summed up the state of knowledge in his time, so Ptolemy, five centuries later, in his great work the *Almagest*, presented a complete treatise embracing the entire range of astronomical science. Altho the system of the World as conceived by Ptolemy was a mere geometrical representation of the celestial motions and did not propose to give a correct picture of the actual state of affairs, it remained for many hundred years the alpha and omega of theoretical astronomy. Throughout the Middle Ages Ptolemy's authority was regarded as almost final in astronomical matters, excepting where it was outweighed by the even greater authority assigned to Aristotle.

Greek astronomy practically ended with Ptolemy, the last great writer of the Alexandrian School. The few writers after his time were commentators and compilers, to none of whom ideas of any importance can be attributed. When the invading barbarians descended from the north, destroying Rome, Greek and Roman civilization were for the time put to an end. Ruin and devastation reigned everywhere. The conquerers seemed to be wholly untouched by the ancient culture of of Asia or anything that might be learned from their new subjects. To some extent their savage state became softened by the Christian religion which they gradually adopted, but above all there was a distinct lack of sympathy for anything that emanated from the heathen Greek and Roman world. But even before the fall of the Roman Empire, a fierce onslaught had commenced on the results of Greek thought. With the spread of Christianity came the determination to have nothing to do with anything that came from the Pagan Pre-Christian world. The great library at Alexandria, collected by the Ptolemies, was burned by the Christian mob under the turbulent Theophilus (389 A. D.). A few years later, Hypatia, the daughter of

Theon, herself a writer on astronomy, was barbarously murdered at the instigation of the bigoted Cyril, and the long dark night of the Middle Ages had set in.

Christianity, with its Biblical traditions now came to the front, and a narrow minded literal interpretation of every syllable of these traditions was insisted on by the leaders of the church. Anything that could not be reconciled therewith was rejected with horror and scorn. The Fathers of the Church asserted that all knowledge was to be found in the Scriptures and in the traditions of the church; that in the written revelation, not only had a criterion of truth been given, but that we had been furnished with all that we were entitled to know. The scriptures therefore contained the sum and substance of all knowledge. By assuming this attitude the church set itself up as the depository and arbiter of all knowledge; and when in the reign of Constantine it became allied with the Civil power, it was ever ready and capable of compelling obedience to its decisions. Thus the Church took a course which determined its whole future career, and caused it to become a stumbling block in the intellectual advancement of Europe for more than a thousand years.

In no branch of knowledge was the desire to sweep away all the results of Greek learning as conspicuous as in astronomy. The spherical figure of the earth, which the Greeks had taught, was especially abhorrent, as were their views on the motions of the planets. Turning over the pages of the early church Fathers, one might imagine that he was reading the opinion of some Babylonian priest of a thousand years before, so similar are the ideas. But in spite of the Patristic system of the World and the efforts of the Church rulers, the ancient germ of scientific truth still lived, and during the latter centuries of the Dark Ages the idea that religion and science were of necessity opposed to each other gradually disappeared, so that by the tenth century it was not an unusual thing to find learned men recognizing that the earth might be a sphere after all; altho the final proof did not come until the voyages of Columbus, De Gama, and Magellan. The shape of the earth was thus disposed of, but the motions of the planets were a riddle of another nature and not so easily solved.

Following the Saracen invasion, Arabian translations of Aristotle began to be introduced into France from Spain. These had to be translated into Latin; and though the translations were doubtless bad, they opened up to a wondering world the treasures of Greek thought. At first the Church was hostile, but its prejudices were gradually overcome, and in 1254 special orders were issued prescribing the study of the treatises of Aristotle. The Aristotelean philosophy now became firmly entrenched in a position which it maintained for four hundred years, until overthrown by the discoveries of Galileo. At this time came also the introduction of the ideas of Ptolemy through the text-book of Sacrobosco, which contained a short account of the Ptolemaic system.

The great revival of learning in the fifteenth century made it clear to any one interested in astronomy that, in order to build further on the foundation laid by the Alexandrian astronomers, it was necessary, first of all, to obtain a thorough knowledge of the *Almagest* of Ptolemy, for up to this time Ptolemy's ideas were known only through the indifferent translation from the Arabic. Through the labors of Purbach and his successor Regiomontanus the first Greek edition of Ptolemy was published in Europe at Basle in 1538. Five years later, in 1543, appeared the great work which was destined to mark the boundary between the Middle Ages and the Modern World,—the *De Revolutionibus Orbium Coelestium* of Copernicus. Copernicus developed mathematically an astronomical system based on the idea, that the apparent motions of the celestial bodies are for the large part caused by the motion of the earth which carries the observer with it, and hence, are not real motions at all. This he showed to be as capable of explaining the observed celestial motions as any existing variety of the traditional Ptolemaic system.

The publication of the *De Revolutionibus* appears to have been received much more quietly than might have been expected from the startling nature of its contents. But the book was in fact unintelligible except to mathematicians of considerable ability, and could not have been read at all generally. Moreover the grovelling preface inserted by the Lutheran Professor Osiander, who had been entrusted with the publication, must have done a good deal towards disarming the hostile criticism which the book must have otherwise invoked. Evidently Osiander's courage failed him; endeavoring to excuse Copernicus (and perhaps himself) he inserted the apologetic lie that the doctrine of the earth's motion was to be considered as a mere geometrical abstraction convenient for purposes of calculation, but in no sense to be considered the true state of affairs!

The Reformation put an end to the religious and intellectual solidarity of the nations, and the resulting contest between Rome and the Protestants absorbed the mental energy of Europe. Science was pushed to the background while theology was thought of first and last. But theology had gone back to the standards of the Patristic writers and again had come to mean the most literal translation of every word of Scripture; to the Protestants, of necessity, since they denied the authority of Popes and Councils; to the Roman Church, from a desire to show how unjustified had been the revolt of the Protestants. Consequently neither side could be expected to be very cordial to the new doctrine which apparently opposed so many texts of Scripture. Luther, in his usual blunt way, had given his opinion of the "upstart astronomer who would assert that the earth moves and thus upset the whole science of astronomy." Even the mild and cultured Melancthon wrote to a friend that the wise rulers ought to curb such unbridled license of mind. Altho viewed at Rome with dislike from the very beginning, is was nearly seventy years before the Church authorities took serious objection to the book of Copernicus. Probably because the heliocentric theory was regarded by them as a subject for academic speculation only, and not as a matter likely to be taken seriously by any sane person, so that there was little fear of the further spread of this pernicious doctrine.

Kepler's success in taking up the problem of the planetary motions and utilizing the observations of Tycho Brahe to finish the task commenced by Copernicus is well known. The laws of planetary motion which bear his name stand as monuments to it. Thus the system of Copernicus was, as it were, brought to completion by Kepler, and all that remained was to persuade the astronomers and physicists that the motion of the earth was not only physically possible, but that it was an actual fact. The accomplishment of this task fell to the lot of Galileo.

A few months before the publication of Kepler's Commentary on Mars, the newly invented telescope was directed to the stars and in the spring of the following year (1610) Galileo published his *Sidereus Nuncius* giving the first accounts of the discoveries made with the new instrument, especially the four satellites of Jupiter and the mountains on the moon. At the end of the little book, Galileo, who for some years had advocated the Copernican system, pointed out the analogy between the earth and the other celestial bodies, and remarked that the discovery of the four moons attending Jupiter in its motion around the sun ended the difficulty of the moon alone forming an exception to the general rule, in that they moved around a planet and not the sun. Before the end of the same year the discovery of the solar spots supplied a new and very striking proof of the fallacy of the Aristotelian doctrine of the incorruptibility of things celestial, while the discovery of the phases of Venus deprived the opponents of Copernicus of a favorite weapon.

Shortly after the discovery by Galileo, the spots on the sun were discovered independently by observers in England, and at two localities in Germany. At one of the latter the discovery was made by the Jesuit, Christopher Scheiner, who later aroused the ire of Galileo by claiming the honor of priority for himself. The controversy which followed developed into a personal quarrel, and unfortunately gained for Galileo the undying hatred of the powerful Jesuit order.

The discoveries of Galileo brought to the fore the old question of the nature of the universe as the burning question of the day, and stirred up a tremendous commotion among the learned Aristoteleans and the Church authorities. In the course of a thousand years the theologians had retreated step by step from the views laid down by the Church fathers; the Babylonian system which they had upheld had given way to the Ptolemaic; the spherical earth; and other abominations had been tolerated; but now when impious hands tried to push the earth out of its imposing place in the center of the universe, and to put spots on the face of the immaculate sun, the theologians turned fiercely to bay. Such things were not to be tolerated by those who argued that the divinely appointed way of arriving at the truth in astronomical matters was by the interpretation of Aristotle or by theological reasoning on texts of scripture. On Galileo, the champion of these vicious innovations, the whole war was at last concentrated. His discoveries overthrew the long cherished traditions of the Peripatetics, and clearly took the heliocentric theory out of the realm of hypothesis; against him the war was long and bitter; and alas, successful.

The history of the trial and condemnation of Galileo by the Inquisition is well known and would be out of place here. It is sufficient to remark that Galileo was cautioned in 1616 against upholding or teaching the Copernican doctrine because certain statements favorable to it, which had been published four years previously in the "Letters on the Solar Spots" were displeasing to the Church authorities. Nevertheless, strengthened by the courage of his convictions, Galileo continued to advocate the obnoxious doctrine, and cited most convincing arguments in favor of it in his great work, the *Dialogues on the Two Chief Systems of the World.* Unfortunately this was seized upon by the Jesuits, whose enmity he had secured through the quarrel with Scheiner, and long eager for the opportunity to settle the old score, they brought to the attention of the church authorities Galileo's disregard of their former warning. On June 22, 1633, Galileo was forced to abjure before the Inquisition; the latter decreeing against the Copernican system of the world; declaring it, "absurd, philosophically false and formally heretical; because it is expressly contrary to the Holy Scripture."

At the time of the discovery of the solar spots (1610) the Aristotelean and the Ptolemaic were the established doctrines of the day, and as such held an almost undisputed position in men's minds. The church had declared in favor of these doctrines, and since it had assumed the position of arbiter of all knowledge, only such ideas and beliefs as were in accord with Aristotle or Ptolemy could expect tolerance from it. Aristotle was the supreme authority to whom all science had to conform. So blind had the subservience become that there were many men who refused to believe even the evidence of their own senses when this was opposed by the precepts of the Aristotelean philosophy. The discovery of the solar spots was made at the time when this philosophy was beginning to be called seriously in question. However, it was many years before Aristotle was overthrown from his high position, and it was many years more before the Church, which had defended him with encyclicals and texts from Scripture, admitted the overthrow. If these long established philosophies were shown to be erroneous, the Church's infallibility must receive a rude shock, in that it would find itself in the position of having approved and supported for a thousand years doctrines in which there was no truth. The Church, thus finding itself about to become seriously embarrassed, did not hesitate to employ whatever means were at his command to force obedience to its decisions and to prevent the spread of the new ideas, at the same time deliberately attempting to stifle the advancement of scientific learning.

Although temporarily successful in its victory over Galileo and the adherents of the new ideas, the victory of the Church was in reality an ignominious defeat, for from all sides speedily came proofs that Galileo and Copernicus were right after all, notwithstanding the Church's dictum to the contrary. Thus the Church soon found itself actually in the unenviable position of having set its authoritative stamp of approval upon a doctrine which was certainly false and impossible. Such things could only react on its influence, and in the course of time must undermine its power. Naturally, this resulted, and, the armor of infallibility once having been pierced, the Church gradually lost its position as the supreme arbiter of all knowledge.

The part in all this played by the discovery of the solar spots, which at first glance one might suppose had no connection with the matter, was by no means a small one; for the controversy over the discovery brought about the quarrel with Scheiner, in turn arousing the Jesuits, who were the prime instigators of the attack on Galileo. There seems to be little doubt of the participation of the Jesuits in this; even Galileo was aware of it and mentioned it in his letters. Further, the spots showed the falsity of the incorruptibility and immutability ideas of the heavens, which were such strong points in the Aristotelean philosophy. In addition, there was the actual evidence for the orbital revolution of the earth to be deduced from the changing paths of the spots across the solar disk. All these events combined to make the discovery of the spots a most important event in the history of the development of scientific knowledge.

While from the standpoint of the historical side of the question the discovery of the solar spots is of the highest interest, considered as a scientific achievement it can hardly be regarded as worthy of especial note. Given the telescope, the discovery must inevitably have been made sooner or later. One recalls Mark Twain's remark concerning the discovery of America, "It was wonderful to find America, but it would have been more wonderful to miss it." Or as Delambre expresses it, "S'il avait une lunette, il a pu voir les taches, il n'y a pas grand mérite à cela."

The telescope was invented in Holland in 1608, and the news of the new instrument spread rapidly over Europe. Those fortunate enough to obtain telescopes soon turned them to the examination of the heavenly bodies. Thus it naturally came about that, among other celestial objects, the spots were discovered independently at several places by different observers at about the same time.

The earliest of these was Galileo. It will be shown that he most probably saw sun-spots with a telescope for the first time at Padua during the summer of the year 1610. It seems that Galileo made no definite announcement of the discovery at that time, at least there is no evidence of any such announcement, but he showed the spots to his friends at Padua, probably as a matter of curiosity. The epoch-making discoveries of the satellites of Jupiter, the phases of Venus, and the triple bodied Saturn were announced in the same year. These discoveries excited an intense interest throughout Italy, and in order to enlighten the incredulous, Galileo journeyed to Rome in the spring of the following year and publicly exhibited the spots and other "celestial novelties" in the Quirinal Gardens of the Carninal Bandini.

The second individual to observe the solar spots with the telescope was the English mathematician, Thomas Harriot. Harriot's first observation was made on the 8th of December 1610 (O.S.).

It is certain that the first publication in Europe giving an account of the spots was by Johann Fabricius, the son of David Fabricius. Johann first saw the spots with the telescope at Osteel in East Friesland on the 27th of February 1611 (O.S.).

The fourth individual who asserted that he had observed the spots independently was Christopher Scheiner, the German Jesuit and Professor of Science in the University of Ingolstadt. Signed with the assumed name of "Apelles latens post tabulam," Scheiner sent an account of his observations in a series of three letters to Mark Welser,* the Mayor or Chief Magistrate of Augsburg. These letters were printed and a copy of the publication was forwarded by Welser to Galileo, of whose observations Welser had already heard, requesting an opinion on the subject. Galileo replied with a similar series of three letters addressed to Welser. In the first Apelles' letter, which is dated November 12, 1611, Scheiner asserts that he first observed the sun-spots some seven or eight months previously. This statement would carry his first observations back to March or April of that year; at approximately the same time that Galileo was exhibiting the spots at the Bandini Gardens in Rome.

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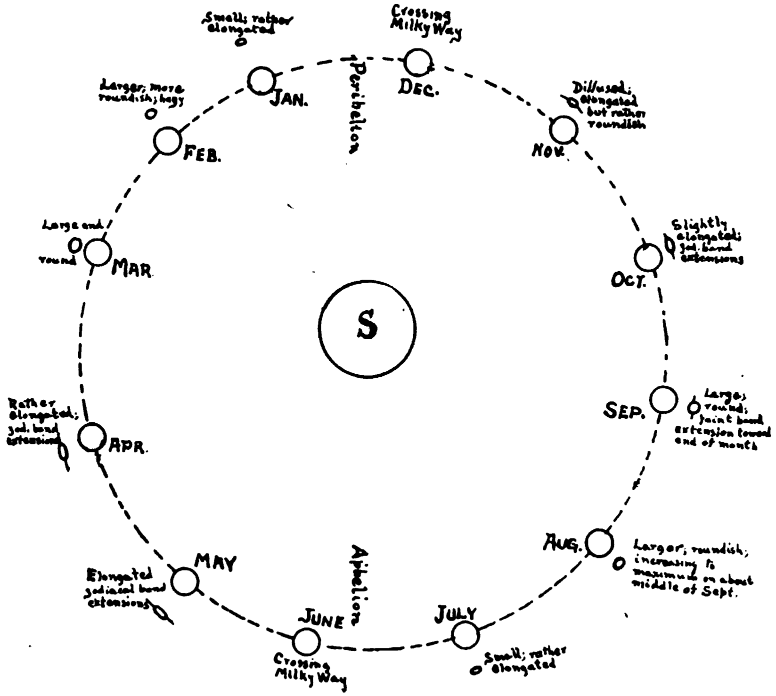
* Born June 20, 1558, died January 23, 1614.

(To be continued.)

GEGENSCHEIN CONFIGURATIONS.

Rev. W. E. GLANVILLE, Ph. D.

Professor Barnard's valuable notes of gegenschein observations made between 1891 and 1899 and reported in POPULAR ASTRONOMY, 1899, April, are the basis of the accompanying diagram. An inspection of it shows that the size and shape of the gegenschein vary periodically in the course of the year; and that at certain times, also periodic, extensions of the gegenschein illumination are noted E and W along the ecliptic, similar to the zodiacal light. The gegenschein moves east along the ecliptic at the rate of about 1° a day. In December and June it crosses the Milky Way and is not then discernible. By reference to the diagram it is seen that in January the gegenschein appears small and slightly elongated. The same notation applies to July, Similarly, February and August correspond, as do March and September; April and October; May and November. Manifestly this annual recurrence of varying size and shape cannot be the result of mere chance and one is naturally disposed to press the question: How may it be accounted for? It has been suggested that the cause may be sought in the configuration of the gegenschein with respect to the earth and the sun each month. The earth is not a perfect sphere but an oblate spheroid. Its axis being inclined 23½° to the ecliptic, with the North Pole pointed away from the sun at the Winter Solstice and maintaining this inclination parallel to itself throughout the year, it follows that the perimeter as presented to the sun along the ecliptic is not uniformly circular. For instance, the rotundity of the earth as presented to the sun in December and June is not precisely the same as that presented to the sun in March and September and there are minute variations during the intervening months. Assuming that the gegenschein is caused by sunlight refracted from the earth's perimeter it is urged that the shape of the gegenschein will vary seasonally on account of the greater or less rotundity of the earth as presented on the ecliptic month by month. This may enter as a factor—but only a minor factor—into the solution of the problem. It is certainly not sufficient to account for the marked change in size as, e. g., between July and September. A more plausible solution is offered as follows:


Small; rather elongated
Crossing Milky Way
Larger; more roundish; hazy
JAN.
Perihelion
DEC.
Diffused; elongated but rather roundish
FEB.
NOV.
Large and round
MAR
Slightly elongated; zod. band extensions
OCT.
S
SEP.
Large; round; faint band extension toward end of month
Rather elongated; zod. band extensions
APR.
AUG.
Larger; roundish; increasing to maximum on about middle of Sept.
MAY
Elongated zodiacal band extensions
Aphelion
JUNE
JULY
Crossing Milky Way
Small; rather elongated

Varying Size and Shape of the Gegenschein During the Year.

Referring again to the diagram it is plain that the gegenschein illumination is at maximum in September. Then it declines in size until in January it is small, after which it increases to maximum in March; thence it declines until in July it is again small; thereafter it increases to maximum again in September. It is unfortunate that no observations are possible in December and June owing to the gegenschein crossing the Milky Way during those months. Arguing from the decline to minimum and the increase to maximum I would predicate that were observations possible in December and June it would be found that *during these months the gegenschein reaches its minimum illumination.* This, I venture to submit, is a soberly reasonable inference. So that we have maximum in September, minimum in December, maximum in March, minimum in June—two maxima and two minima in each year. Advocates for the Light Pressure theory as accounting for zodiacal light and gegenschein phenomena may here inform us that these periodic maxima and minima of gegenschein illumination support their theory, on the ground that during March and September the earth is exposed to the more active zones of solar activity, because the sun's axis is inclined 83° to the ecliptic, with the North Pole pointing towards the place occupied by the earth in September. We reply to this contention by asking them to account for the E and W zodiacal band extensions witnessed in October and November and in April and May; and also to account for the regularly varying *shape* as well as size of the gegenschein in the course of the year. Rather are we disposed to attribute the periodic variations in size of the gegenschein to rythmically *varying distance from the earth. At maximum we consider the gegenschein to be at perigee*; *at minimum to be at apogee.* The E and W zodiacal band trails of the illumination demonstrate the *continuous extension of the zodiacal band material along the ecliptic.* Connecting this with the zodiacal light appearances on the E and W horizons which extend sometimes 90° from the sun as seen at or near sea level and even clear across the sky, the gegenschein and zodiacal light sometimes merging, as seen from altitudes of 1½ to 2 miles above sea level, we have confirmatory evidence of the Earth Ring theory of the Zodiacal Light which I have discussed in former papers. The marked difference in size between the gegenschein illumination at maximum and minimum respectively may be regarded as indicating an ellipse of rather high eccentricity, subject perhaps to lunar perturbations, for the fact of the Moon Zodiacal Light shows that the zodiacal band material—whatever its nature is—is intermediate between the moon and the earth.

Note:—A point I have nowhere seen investigated in connection with studies of the gegenschein and zodiacal light is *the bearing of refraction* on these phenomena. The denser the atmospheric strata the more intense and concentrated is the refraction of sunlight from the earth's perimeter. In the higher and more rarified strata refraction is proportionally less and consequently refracted light reflected from an object on which it falls is correspondingly more dispersed. And not only the density of the atmosphere (which is greatest at sea level) but also the *temperature* of the atmosphere affects the intensity of refraction. From our north temperate latitudes we view the ecliptic at night, during most of the year, through the densest strata of the atmosphere. In the tropics the conditions are different even at sea level when the question of temperature is considered. There, particularly at high elevations, the zodiacal light shows up more conspicuously.

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REPORT ON MARS, No. 13.

WILLIAM H. PICKERING.

LATITUDES AND LONGITUDES.

An investigation has been made of the best method of determining latitudes and longitudes on Mars. While it is not yet complete, a preliminary statement may be made in time for this opposition. The best method of determining longitudes does not require a micrometer, but only a position circle. The thread is set parallel to the axis of the planet in accordance with the ephemeris, and the time recorded when the given point and the center of the northern polar cap are equally distant from the thread. This method has given excellent results in the hands of Dr. Lowell, and while there are theoretical objections to it, yet in practice it has proved very satisfactory. A correction must be made for the phase, and also for the slight eccentricity of the cap, the center of which according to Dr. Lowell in 1903 lay in longitude 195°, latitude 89°.4 (Bulletin No. 18).

The best method of determining latitudes is by means of the micrometer, a measure being made just before and again just after the point reaches the central meridian. If a micrometer is not available, very nearly as good results may be obtained by a series of drawings. Since it is only necessary to locate the given point on the disk, this observation need not require very much time. These methods of measurement can be used to best advantage near the time of opposition. While at other times the correction for phase is larger, this may always be made by graphical methods, making the measures on a large scale drawing, constructed from the ephemeris.

When it is desired to locate points not seen to transit the central meridian, the micrometer method is the best. Here too, much computation may be saved by graphical methods which are available for this purpose, since no high degree of accuracy is possible in any case on so small a disk as the planet presents. When a point is sharply defined and well seen, we should be able to locate its position within rather less than 1°, that is to within less than forty miles, or sixty kilometers. Orthographic projections of the sphere eight inches in diameter may now be purchased of the J. L. Hammett Co. of New York and Boston, and the measures plotted directly on them, a correction being made later for the inclination in latitude of the line of sight.

Besides their obvious purpose of map making, there are two other reasons why determinations of position should be secured. First to settle the period of rotation of the planet, which controls future computations of the ephemeris, and second to determine the extent and direction of the local shift of the various markings upon the surface. While the shift is in most cases so slow as to be noticeable only from one presentation to another, yet in the case of the polar marshes, the Syrtis marsh, and the polar bands, the change may be watched occurring from night to night, and sometimes even from hour to hour. The gradual shift is most marked among the dark markings of the planet in the southern hemisphere, but it is of more interest among the lakes and canals.

To determine the period of rotation, observations of the following points, which seem to be fairly stationary on the disk, are recommended: The promontories of Hamonis and Edom, especially the latter, and the bay where Euphrates enters Sabaeus. The first two are not marked on Schiaparelli's map given in Report No. 1, but may be described as the promontories following the Syrtis Major and preceding the forked bay of Sabaeus. Phoenices and Titanum at the northern extremity of Sirenum also appear to be excellent points, although the latter was suspected of some motion during the last opposition. The center of Solis Lacus according to most observers is fairly stationary. These points have all been widely observed in the past.

Points which clearly shift through a considerable range are Oxia Palus at the northern extremity of Margaritifer, the junction of Nectar and Aurorae, and the Syrtis minor. Several of the lakes appear to shift more or less; Siloe, (known also as Dirce,) Juventae Fons, Propontis, Trivium Charontis and Ismenius. The extent of the maximum shift from the mean ranges in general from 3° to 5°, 120 to 200 miles. The mean latitudes and longitudes of these various objects are given in Table I. The mean longitudes of Aryn on the present ephemeris is 359°.2. Its latitude ranges from +6°.8 to −5°.6, mean value +0°.1. Since its axis is usually inclined about 15° to the meridian, its longitude would obviously vary appreciably from this cause alone, if for no other. In point of fact Lau's observations make its longitude 355°.9 when reduced to a common standard with the other observers, while those of Wislicenus and of Lowell in 1894, similarly reduced, make it 0°.1, total range 4°.2.

TABLE I.

Latitudes and Longitudes of Certain Points.

For Rotation		
Solis Lacus, center	−26°.9	86°.0
Phoenicis	−13.6	107.5
Titanum	−18.9	169.6
Hammonis	−11.2	315.5
Sabaeus, Euphrates	− 6.5	337.7
Edom	− 7.4	352.3
For Shift		
Margaritifer (Oxia)	+ 8°.1	19°.0
Aurorae Nectar	−26.1	64.3
Syrtis Minor	− 6.5	255.6
Lakes for Shift		
Siloe	+34°.0	3°.9
Juventae Fons	− 1.0	64.0
Propontis	+49.0	175.0
Trivium Charontis	+17.2	198.9
Ismenius	+42.1	335.7

The Polar Cap.

There seems to be considerable variation in the date assigned by different observers for the maximum size of the northern polar cap. That it should differ somewhat in different years we may well believe, but that the difference should be as great as the various observers indicate appears incredible. It is an observation easily made, by simply measuring a series of carefully executed drawings, and then dividing the diameter of the snow cap by that of the planet. The accuracy which can be secured by this means is much greater than one might naturally expect. Thus a comparison of observations made at the same time by Professor Douglass and the writer showed that the average deviation between the results was 2°.2, or 85 miles (136 km). This amounts to one fiftieth of the diameter of the planet, which corresponded to about 0″.3 at that time (Report No. 3).

In 1882 the maximum size was reached according to Schiaparelli at more than one month after the vernal equinox (Flammarion I, 460). This would correspond to ⊙ = 13°.8 + or to M. D. March 29 +. The latitude reached was 67°.5. Turning to Lowell's "Mars as the Abode of Life", p. 268, we find two determinations of ⊙ for the maximum size, 8° in 1897, and 273° in 1907. The latter was not a favorable year for the observation. These longitudes would correspond to the Martian dates March 17 and December 16. The mean latitudes reached were 51°.5 and 45°.0. In the Report of the Mars Section of the B. A. A. for 1893 are given two curves indicating that the maximum in 1898-9 and 1900-1 came as much as 180 days before the summer solstice. This would correspond to ⊙ 9°.5 or M.D. March 20. There are however only half a dozen observations extending back as far even as 200 days in the first curve, that is to the equinox, ⊙ 0°.0, and only one preceding the supposed maximum in the second. The dates are therefore very uncertain, giving in fact only maximum values of ⊙. The mean latitudes reached are 64° and 64°.5. The dates thus range from December 16 to later than March 29, and the latitudes from 45° to 67°.5. Regarding Dr. Lowell's two observations which differ widely from one another, no details are given, the other three determinations are obviously unsatisfactory.

It might appear at first sight that neither 1913 nor 1915 were particularly favorable years in which to determine these two quantities, since in both cases the date of maximum size came appreciably earlier than the date of opposition. On examining our results however we found that only one recent opposition, that of 1911, would have been more favorable, and that there would be no further opportunity to make a satisfactory determination for a number of years.

In Figure 1 are shown all the observations that were obtained in Jamaica during the opposition of 1913-4 and all of those obtained in 1915 through November 30. The former are indicated by dots, the latter by small circles. The ordinates represent degrees of Martian latitude, and the abscissas degrees of solar longitude ⊙. These latter are given beneath the curves, and below them the corresponding Martian dates. At the top are given terrestrial dates, the upper row those for 1913-4, the lower those for 1915-6. The two short vertical lines indicate the dates of opposition, the left hand one that of 1914, the other that of the present year. The smooth curves show the mean positions of the snow line in the two Martian years, and indicate, as already pointed out in Report No. 12, that the present year was the colder, or at all events the more snowy upon Mars. On comparing the drawings of the two years this difference is quite noticeable.

On carefully reading over our own notes, we found that on only one occasion during each of the two years considered, was it at all likely that prior to ⊙ 350° it was the snow itself that was observed. On all the other dates the bright area was described either as cloud, as yellow, or as greenish. In other words as long as the polar cap was increasing in size, it seems to have been concealed by something,—undoubtedly cloud. As soon as this cloud cleared away, at about ⊙

350°, the brilliant area appeared, and was invariably described as white. Immediately after this it began to diminish in size.

A large bright cloud visible in the Martian December in 1907 may well have been mistaken by Lowell for snow, while the lack of brilliancy of the polar cap in 1898 and 1900 may have led the British observers to doubt if what they saw during their earlier observations was really the cap at all. Lowell's result in 1897 is probably more nearly correct. The four crosses indicate the positions of the maximum size as determined by Schiaparelli, the British observers, and Lowell in 1897. The determination by the latter in 1907, ⊙ 273°, would not fall upon the sheet. It will be remembered that Schiaparelli gives merely a minimum longitude.

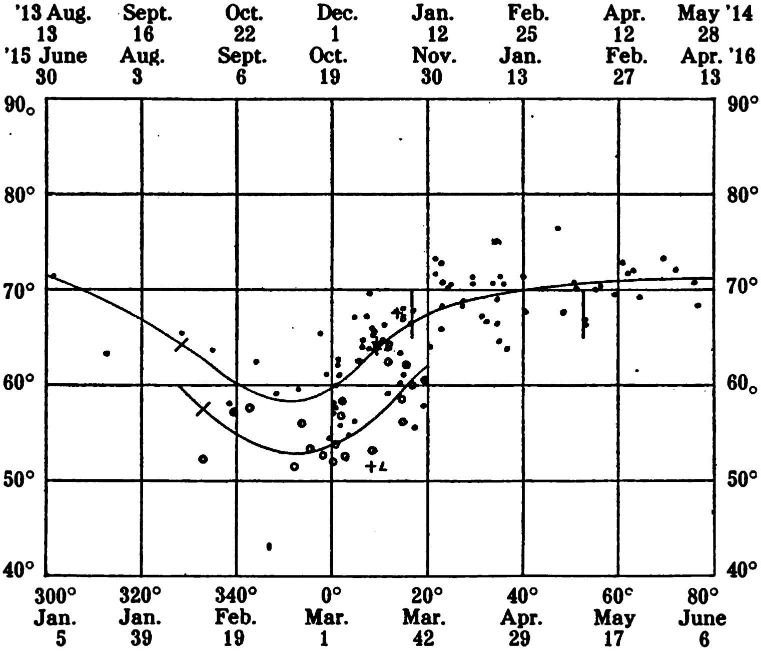


FIGURE 1.

The dark band surrounding the polar cap, and due to its melting, was first detected in 1913 at ⊙ 328°.2, M. D. January 53, and in 1915 at ⊙ 332°.9, M. D. February 5. These dates are indicated by short diagonal lines. This band and the study of the curves leads us to believe that the size of the cloud could not in general have been very different from the size of the snow beneath it, except in the case of the observation at abscissa 345°, when the cloudy area was unusually extended. It gives us at all events a southern limit in latitude. Whether when we observed it, during the Martian daytime, snow was actually falling, or cloud and mist were merely rising from the melting snow that had fallen during the previous night, we cannot tell, but observations made later in the Martian year lead us to believe that at that time at least most of the precipitation occurred at night.

Returning to the Figure, at the time of opposition a deviation of 5° of latitude from the line giving the mean diameter of the snow cap, would represent an angular deviation of $0''.6$, but at abscissas 320° and 60° in 1913-4 the angular deviation would be reduced to about $0''.3$. The later deviations however seem to be no greater than those recorded near opposition. While as a rule they do not exceed 5°, we find a series of large deviations in 1913-4 occurring at fairly regular intervals at about solar longitudes 345°, 0°, 17°, 36°, and 53°, at which times the cap seemed to be unusually large. The mean longitude of the central meridian at the time that these observations were made was 357° ± 30°.

This cannot indicate an elliptical shape of the spot, since in that case larger diameters should also be found at 180° from this position, or in longitude 177°, which is not the case. The most probable explanation seems to be that the cap was really larger in this position, owing to its greater extension towards the sunrise or sunset limb. It could hardly be the latter, but clouds or snow might persist for a time after sunrise in certain localities under suitable conditions, and thus apparently increase the size of the cap on that side. Measuring 90° towards the sunrise limb from longitude 357° brings us to longitude 87° which lies slightly to the west of the following or western border of the Acidalium marsh, the largest of the four marshes surrounding the polar cap, and the only one that was conspicuous after February. This is exactly where we should expect to find cloud at sunrise, according to Reports Nos. 3 and 4, and also according to the observations already made at this opposition.

In Report No. 4 we noticed the slow increase in longitude of the twin polar bays, as they gradually shifted to the west, as the result of the daily evaporation and nightly deposition of their moisture, combined with its southerly motion toward the equator. Nine measures of favorable drawings of the southern end of the following side of Acidalium, made during the same period, give its longitude as follows:— Nov. 26 36°, Dec. 1 42°, Dec. 4 40°, Jan. 5 41°, Feb. 8 47°, Feb. 10 45°, Feb. 12 50°, Mar. 20 60°, Apr. 21 60° (?) The same gradual change of position it will be seen occurs.

The inclination of the planet's axis to its orbit is determined by observations of the position angle of its polar caps. If the northern cap is more extended towards the sunrise than towards the sunset limb in certain longitudes, owing to the deposition of snow or cloud, it is clear that a correction not wholly negligible, due to this cause, should be taken into consideration in future determinations of the inclination of the axis.

Using the smooth curves of the Figure as average values, we find that the snowy season reached its maximum in both years shortly after abscissa ☉ 350°, corresponding to the Martian dates of February 39 and 43, and that in latitude 60° the snow persisted from February 20 to March 2 in the former opposition, and from January 53 until March 32 in the present one. These seem rather short seasons to us for so high a latitude, when counted by months, although the former lasted for 38 days and the latter 91. This is due without doubt to the small amount of water on the planet. The lowest latitudes reached were 58° and 53°, giving a difference of 185 miles (295 km).

OBSERVATIONS IN NOVEMBER.

On November 4, M. D. March 17, a drawing was made with the central meridian ω in longitude 112°. The polar cap was white and brilliant, there was no cloud on the terminator, but a very slight haze at the south pole, and the southern limb was the same brightness as the centre of the disk, which shone clear and red,—No. 9 on the color scale with tungsten, and No. 14 with the standard blue. There was therefore no cloud on the disk. Nevertheless all the detail, save the polar cap and the grey band to the south of it, was excessively faint. The greys and greens had as yet in no way developed, all the water apparently being at first deflected to other points of the planet, leaving the surface red and barren. This was true also at the last opposition, this longitude being the last to develop at that time. The region about Solis Lacus, that is Thaumasia and the Solis itself were a light uniform grey. Next in visibility came a light bay pointing to the north, and located some 20° to the north of Nodus Gordii and slightly to the west of it, in longitude 131°, latitude +25°. This same marking, although rather more distinct at that time, had been recognized in 1913, M. D. December 54. As far as the writer is aware it had never been seen before, nor since that date, until this year. The darkened area was of perhaps double the size of Solis Lacus, but exceedingly faint. Portions of Pyriphlegethon and Gigas were suspected. In 1913 the Solis was first seen December 25, M. D. March 25, and within five days had developed in great detail.

November 13, ω 29°, M.D. March 25; although the seeing was fair, and the Acidalium marsh extended nearly 0.4 way across the disk, the southern maria were exceedingly faint, their northern boundary extending east and west in a straight line without detail and without darkening. They were indeed only detected by their pale green color. The marsh showed slight polarization when examined with a double image prism and quartz plate, indicating a surface, liquid in part.

November 17, ω 357°, M. D. March 30. Sabaeus showed the first signs of development as a slight projection towards the north, and darker than anything save the Acidalium marsh. The southern maria were green, the northern grey. The most unexpected feature was the persistence of the north and south band, which starting from slightly to the east of the marsh stretched straight across to Sabaeus. Its western border was hazy, and its breadth was about 300 miles. It lay in the region between Gehon and Indus. The next day it had become markedly narrower. The brightness of the deserts was 7 and the band 6. Perhaps the most interesting thing about it was a slight tendency towards the double effect. Conditions were unfavorable however, and no conclusion was reached.

If we compare Figure 2 with the four figures given in Report No. 11, we shall be struck with the different development in different regions of the planet. Thus, while the Martian date is later in the present Figure, and the Acidalium marsh more developed than in any of the others, save Figure 3, yet Sabaeus itself is no further advanced than in Figure 1. As compared with Figure 2 the marsh in the present Figure is more developed, and Sabaeus less so. As compared with Figure 3, Sabaeus is in a most undeveloped condition, although the Martian date is four weeks later. Compare also with the colored Figure 2, issued with the Index, which was drawn but six days later in the Martian year than the present figure. Sabaeus was still connected with the dark band when last seen November 19, and the projection of the Forked Bay had become slightly more pronounced. The southern boundary had also appeared, so it is quite possible that its development will take place quite rapidly before we next observe it in December. In the mean time it is hoped that some of our Associates

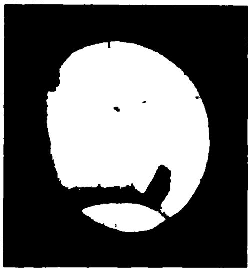


Fig. 2
1915 November 17
Martian Date March 30
357° 7″.8

in Australia or Asia may watch and record the gradual process of its development in that case, and send us notes and drawings of the same. In the mean time we may ask (*a*) will the north and south band continue until Sabaeus is as far advanced as it was when the band disappeared in 1913, Figure 2, or (*b*) will the band cease immediately, now that the polar cap has become equally reduced in size? The two short lines in the Figure indicate the position-angle of the poles. Obviously there is no trace of Aryn, so far in the Martian year.

In Report No. 12, Table III, line 8, it was assumed that the north and south band had disappeared on the Martian date of February 53. It is now shown to have been clearly visible on March 32, or 35 days later, thus removing this phenomenon from the list of those which came early this year, and adding it to those which came late. On comparing the phenomena of these two oppositions we see that besides the changes in place occurring on Mars, we have also changes in time. The former are well illustrated by the unexpected appearance of Thoth in 1911 and 1913, as illustrated in Report No. 7, Plate XXXII, and also by the development of the twin polar bays Propontis and Castorius, mapped in Report No. 4,—where a swamp 1200 miles in length developed, which in previous years had appeared only as a small and inconspicuous lake, barely 100 miles in diameter. It is much as if Lake Ontario should suddenly develop into a swamp reaching from New York to Omaha, and as broad as the lake is long.

It is possible that some day we may be able to predict these developments in advance, but at present we see not the slightest chance of being able to do so, and can only record them with all their attendant phenomena as fully as possible, to furnish data to be used by the astronomers who follow us. With regard to the changes in time however, we are in a somewhat different position. Comparing the present and the past oppositions, we find that in both cases the snow cap reached its maximum development at about the same date, but that at the present opposition the snow extended nearly 200 miles or five degrees farther south than it did at the other. If in the case of our own planet the isotherm of melting snow should one year extend 200 miles farther south than the next, that one year for instance it did not extend beyond New York, and the next should reach as far as Richmond, we should not be surprised to find that vegetation was a few weeks delayed in consequence in its development. With the longer year upon Mars, the delay might be still greater than with us.

What we actually find by Report No. 12, Table III, is that while the Acidalium marsh, situated 200 miles farther south than before, at the edge of the snow, developed this year four weeks earlier than in 1913, that the Syrtis marsh and vegetation, far to the south of Acidalium, developed from four to nine weeks later. With such brief and limited observations we cannot of course claim to have demonstrated a connection between the phenomena considered, but we can at least say that a connection between them seems plausible, and that a later development in a colder year is what we should naturally expect. It will certainly be of interest at the next opposition to see if these results are in any way confirmed. It would at least suggest that in the future we might predict approximately the week of appearance of any given marking by the size of the snow cap. It will also further interest us if a colder winter on Mars, as indicated by our observations of the past September, October, and November should be followed by a colder or more snowy winter on our own planet.

Another point which the writer wishes to make clear is that in order to determine the exact time at which the various features on Mars develop, it is most important to secure continuous observations of them from the earth. These can only be obtained by means of a series of stations located all around our planet, with their reports sent in to one central authority. This is the main object of the organization known as the Associated Observers of Mars, and it is greatly to be hoped that some of its members located on the other side of our globe will be willing and able to secure the early morning observations which are necessary during the period two or three months preceding the date of each opposition.

On November 18 the duplication of the north and south band was again suspected, but the continuance of unfavorable conditions, mainly wind, again rendered its confirmation impossible. A dark spot visible the previous night in the region of the Forked Bay was now invisible. The continuous canal named in different sections Protonilus and Deuteronilus had clearly developed. The cloud which usually follows the Acidalium marsh was well seen, though the marsh itself was invisible. Since the latter was within 60° of the central meridian, it was presumably at this time covered by the cloud. The polar band was invisible, though well seen the previous night, see Figure 2. Mars was 0.1 magnitude brighter than Procyon, but still 0.6 fainter than Saturn.

November 19, ω 315°, M. D. March 32. The cloud at the south pole was white in color, not yellow, but was clearly less brilliant than the snow. A minute cloud was noticed bounding the snow cap on the south near longitude 0°. It was within perhaps two hours of the central meridian. Ismenius Lacus had developed, but was still a delicate object. The southern boundary of Sabaeus was seen for the first time. It certainly was not visible November 17 or 18, although on the latter date the Sabaeus region was drawn as slightly darker than that to the south of it, showing gradual development.

The writer confirms the result of other observers that when the seeing is excellent, looking through a piece of very light yellow glass slightly improves the definition. On approaching the terminator the Syrtis disappeared at a distance of 40° from the central meridian. The duplication of the north and south band was suspected for the third time, and again without reaching any conclusion. Seeing 9.

The position angle of the band just before it crossed the central meridian was found to be 9°, i.e. 9° west of north as measured on the planet. In August and September it was inclined about as much to the east of north. It will probably finally develop into the canal Gehon. The first color sketch was made this year, ω 341°. The green of the Sabaeus region was very faint, apparently fainter than last year at this Martian date.

November 21, M. D. March 34, ω 293°. The difference in brightness of the desert regions on either side of the Syrtis is very striking, that preceding it, between it and Thoth, being only 4, while following the Syrtis, that is to the west of it, it is 6. The south pole was 8, and of a greyish yellow. The Syrtis marsh was grey, brightness 2. The southern maria like those at the north were grey. Libya was the greenest region, but even there the color was not marked. The equatorial limb was only slightly brighter than the center, indicating that the disk was free from cloud. No clouds were detected on either the limb or terminator. The south pole was recorded as of the same color as the snow, though less brilliant, 9.

The scale of Canals described in Report No. 7 was first tried with Mars in June 1914, but the planet was then so remote that the results were unreliable. It was next tried this year November 19, but with Scale J, drawn with a number 3 pencil. This scale matched Sabaeus and the Syrtis marsh very well, but was much too dark for the canals. The results were unsatisfactory, but the necessity of matching the canals exactly in density was made very obvious. The color and brightness of the paper were found to match the surface of the planet satisfactorily when a magnification of 660 was employed. With this power one millimeter on the scale corresponds to 0″.065. Scale E drawn with a number 4 pencil was now substituted for J, and the following results obtained, ω 315°, seeing 7, Syrtis marsh measured east and west through middle 0″.39, Deuteronilus 0″.32, north and south band 0″.13, Sabaeus 0″.39. Reducing these for the inclination of the surface at the time of observation, gives us the following breadths:—Syrtis 233 miles (374 km), Deuteronilus 194 miles (310 km), north and south band 95 miles (152 km), and Sabaeus 250 miles (400 km). Measurements made from a drawing on November 19 give us for the Syrtis

272 miles, deviation + 39, for Deuteronilus 182 miles, deviation —12, for the north and south band 58 miles, deviation — 37 and for Sabaeus 317 miles, deviation + 67. Considering the remoteness of the planet at the present time, and the consequent fact that 52 miles equal 0''.1, these deviations are no greater than we might naturally expect. While for these comparatively wide canals it is believed that the scale gives more accurate results than the drawing, it is thought that for still narrower canals the scale will give very much more accurate results. These observations indicate that there is no large systematic error introduced by the scale readings, at least as far as the drawings can serve as a standard of comparison. Later, when more and finer canals are visible, we shall test the method for accidental errors.

November 23, ω 308°, M.D. March 36. The Syrtis marsh was but little darker than the region surrounding it, and it is doubtful if it now contained much water. Heavy clouds were seen on the terminator to the south of the Syrtis. A very fine line of cloud bounding Protonilus on the north and crossing the central meridian was detected. Clouds seem to favor the northern and following sides of dark markings at all seasons of the year. An east and west rift in the snow cap was suspected. Orontes glimpsed, but still doubtful. There was no trace of green in the Syrtis, although the seeing was 11. A little was suspected near Libya.

November 26, M.D. March 39. At 15h 20m when about 30° west of the central meridian Casius was very marked and dark; two hours later when central is seemed much less so. In this longitude the southern maria are clearly greenish. A minute white cloud was detected near the central meridian half-way between the Syrtis and Thoth; the next night it could not be found.

November 27, ω 242°, M. D. March 40. Polarization suspected in the canal Nilosyrtis, but not seen anywhere else. A white area was noted near Novissima Thyle in latitude —70°, and measuring about 1000 miles across, which was as white and as brilliant as the northern polar cap. It was surrounded by a fainter belt of cloud. It seems possible that it was the beginning of the southern snow cap, from a portion of which the clouds had temporarily cleared. Seven canals were visible this evening.

November 29 a bright cloud was seen on the northern limb extending half-way to the central meridian. A large marsh, Propontis, was visible near the terminator.

TABLE II.

Data of the Observations.

No.	1915	⊙	M. D.	Long.	Lat.	Sun	Diam.	Seeing
22	Nov. 4	8°.2	Mar. 17	112°	+17°	+3°	7″.2	10
23	" 13	12.0	" 25	29	18	5	7.7	8
24	" 17	14.4	" 30	357	19	6	7.8	7
25	" 18	14.8	" 31	329	"	"	7.9	6
26	" 19	15.4	" 32	315	"	"	8.0	10
27	" "	"	" "	341	"	"	"	8
28	" 21	16.4	" 34	293	"	7	8.1	8
29	" 23	17.3	" 36	308	"	"	8.2	11
30	" 27	19.2	" 40	242	"	8	8.5	7

The following lakes and canals were seen:—

Nov. 4 **C** Pyriphlegethon, Gigas, Eurotas.
Nov. 13 **A** Tanais.
Nov. 17 **A** Callirrhoe.
Nov. 18 **F** Protonilus, Deuteronilus.
Nov. 19 **FA** Nilosyrtis, Protonilus, Deuteronilus, Gehon. Ismenius Lacus.
Nov. 21 **F** Nilosyrtis, Thoth, Nepenthes, Protonilus. Ismenius Lacus.
Nov. 23 **F** Nilosyrtis, Protonilus, Deuteronilus, Orontes (?) Ismenius Lacus.
Nov. 27 **E** Nilosyrtis, Casius (formerly referred to as Boreosyrtis), Thoth, Nepenthes, Cerberus, Eunostos, Alcyonius.

Communications have been received from Messrs. McEwen and Lau, of the Associated Observers. Both succeeded in seeing the north and south band. This is most important as corroborative evidence of a striking phenomenon, first seen at its maximum dimensions in 1913 and 1915, and first seen upon a smaller scale in 1911, at the observatory of M. Jarry Desloges (Observations 3, Plates 7 to 10). So striking and conspicuous indeed is the phenomenon when at its maximum, that we can scarcely doubt that it is a new development upon the planet. The very fact that it was visible to Messrs. McEwen and Lau with only 5-inch and 4-inch telescopes, when its breadth and density were well past their maximum, and the band had already become comparatively inconspicuous, indicates that had it appeared of its full size and density at earlier oppositions, it would certainly have been discovered by some one. If a phenomenon of this size, covering over a million square miles of surface upon the planet, is really a new development, it is unnecessary to call further attention to its importance.

On September 27 Mr. McEwen writes "A fainter shading extended southwards from Lacus Niliacus to about the position of Margaritifer Sinus. This shading probably included Indus and Hydaspes....It was doubtful if Margaritifer Sinus was visible, although Indus and Hydaspes were clearly seen, the latter as a faint band lying in a N and S direction." This is where we saw the band on October 9. On September 28 he writes "Indus and Hydaspes presented the same appearance as yesterday." September 30, "Indus broad and diffused, starting from Mare Acidalium. It was faintest at the N end; towards the S end at Margaritifer Sinus the tint deepened, making the E boundary sharp and the W somewhat softer." If we examine Figure 2 we shall see that his description of the difference between the eastern and western sides is fully confirmed, although by November the band had gradually shifted its position in an easterly direction, so as now to connect the eastern side of the Acidalium marsh and the Forked Bay of Sabaeus.

Professor Lau sent a drawing made November 9, which is practically identical with Figure 2, except that by that date the northern end of the band had not advanced quite so far, and consequently joined the southern end of the marsh to the Forked Bay. The band presents the same characteristics of the sharp eastern and hazy western borders.

KING WINTER'S GALAXY.

Resplendent 'mid bespangled skies.
King Winter's galaxy is seen,
Where Pleiades wink tiny eyes
And Taurus in red fury lies,
And bright Capella reigns—a Queen!

Where like some background in the sky
Yon Jacob's Ladder gleams between
Orion's gems and Gemini,
When Canis Minor's sun near by
And Sirius adorn the scene.

Supernal—silent—and sublime!
The same today as they have been
Since Nature woke terrestr'al time
Or pyramid was in its prime,
Or Earth with life's first dawn was green.

CHARLES NEVERS HOLMES.

ASTRONOMICAL PHENOMENA IN 1916.

ECLIPSES.

In the year 1915 there were only two eclipses. In 1916 there will be five eclipses, three of the sun and two of the moon. For the figures and detailed description of these eclipses the reader is referred to the paper "The Eclipses of 1916", beginning on page 1 of this number.

THE PLANETS.

The accompanying charts, Figures 1 and 2, will be useful in following the courses of the planets for the year. To any one who has a little acquaintance with the appearance of the sky, the brightest of the planets, Venus and Jupiter, will be easy of identification whenever they appear. For those planets which more nearly resemble stars and for those not visible to the naked eye, it is necessary to have some means of knowing their position in the sky. Since they will all be lost in the rays of the sun, at certain periods of the year it is desirable to know when and where their reappearance may be expected. The charts do not show the positions of the sun although they do show its path as the heavy line, the ecliptic, which intersects the equator at the extremity of each diagram. The position of the sun along this path can be found with accuracy sufficient for the purposes of the charts by remembering that the sun moves from 0^h to 24^h at the rate of two hours a month, beginning on March 22. By locating the sun in this way it is possible for any one to decide whether or not a given planet is to be seen as a given date.

Mercury completes about four revolutions about the sun in the course of the year. Since its orbit is relatively small it is always in the same part of the sky as the sun. It therefore, as seen from the earth, partakes of the apparent motion of the sun toward the east. At three periods in the year however its motion coupled with that of the earth is such as to make it appear to move westward in the sky or, as it is called, to have retrograde motion. It begins the year in Sagittarius, moves into Capricornus and describes a loop there in February and March, then proceeds eastward until June when it moves retrograde for a short period in Taurus, then proceeds eastward again until October, when it moves westward for a short time in Virgo, then turns and moves eastward again and ends the year near the eastern boundary of Sagittarius, having completed a little more than one circuit around the sky. This planet is visible only at very limited periods. On and near the following dates it will be visible in the east just before sunrise: March 1, June 29, October 20; on and near the following dates, on the western horizon just after sunset: January 20, May 12, September 9.

Venus will start its course for the year in Capricornus. It will move continuously eastward until June when it will turn and move westward in Gemini during June and July. About August 1 it will again start eastward and continue in that direction for the rest of the year. Because of its retrograde motion it will end the year in Scorpio, about four hours east of its starting point.

This planet will begin the year as the bright evening star, low in the west at sunset. It will rise higher and higher in the evening sky until April 23, when it reaches a point of greatest elongation east of the sun. It then will be found lower

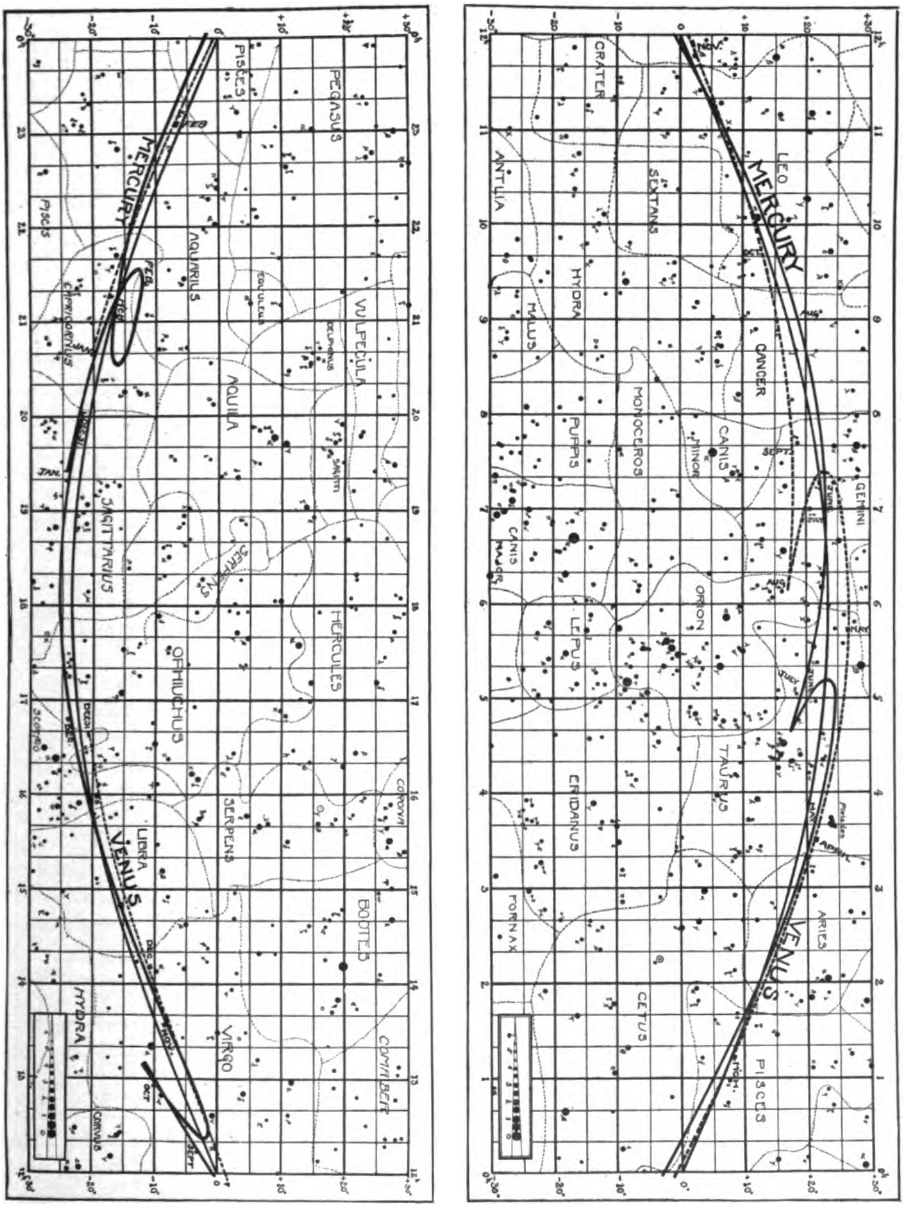


Fig. 1. Aparent paths of the planets Mercury and Venus among the stars during the year 1916.

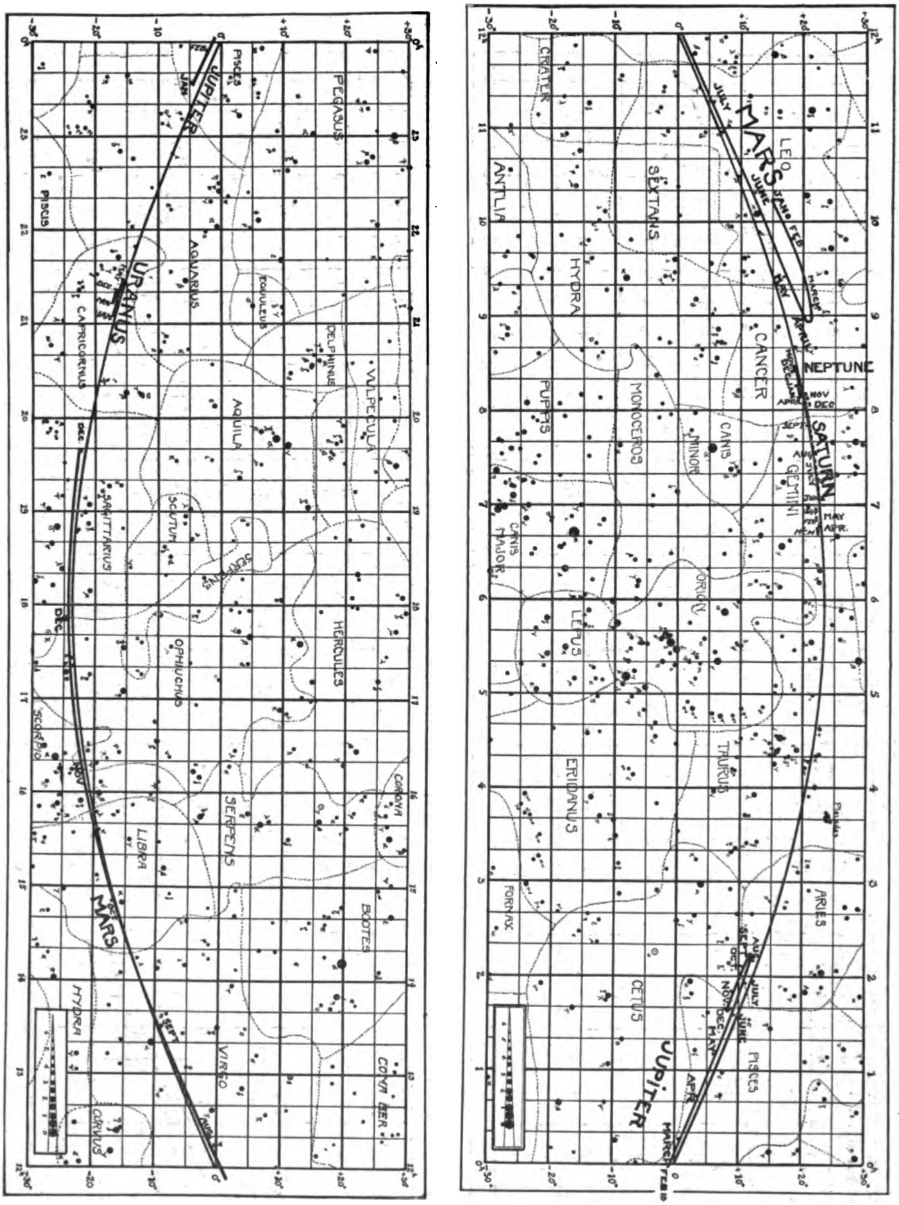


Fig. 2 Apparent paths of the planets Mars, Jupiter, Saturn, Uranus and Neptune among the stars during the year 1916.

Note:—Figures 1 and 2 were drawn by Carl D. Hibbard at Goodsell Observatory, the remaining figures were copied from the *American Ephemeris*.

and lower in the west and on May 27 will attain its greatest brilliancy. It will continue to move nearer to the sun and in June will no longer be visible. On July 3 it will pass between the sun and the earth. It will then swing out on the west side of the sun and be the bright morning star in August and will reach a point of greatest elongation west of the sun on September 12. It will remain a brilliant object in the morning sky throughout the remainder of the year.

Mars will begin the year with a motion westward in the constellation Leo. It will continue to move westward for the first three months and will then turn and move toward the east. It will keep ahead of the sun in its eastward course throughout the year. The sun will however be gaining upon it, and Mars will end the year low in the west at sunset. Mars will therefore be visible in the sky throughout the year. Mars will come to opposition in February, but it will not be a very favorable opposition, the distance from the earth being nearly twice as great as at the most favorable one.

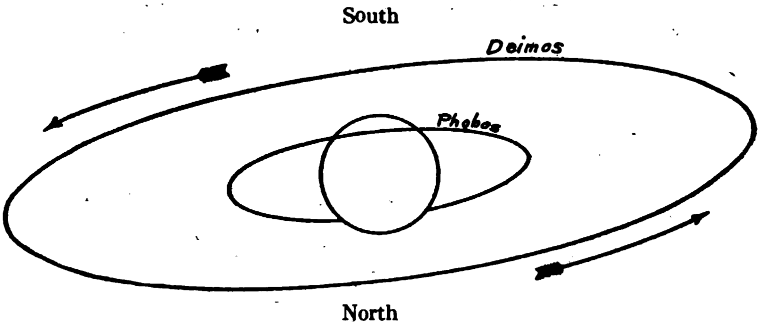


FIG. 3. SATELLITES OF MARS, 1916.
Apparent orbits of the Satellites of Mars at date of opposition, February 9, 1916, as seen in an inverting telescope.

Figure 3 shows the orbits of the satellites of Mars at the time of opposition.

Jupiter will move eastward starting from a point in Pisces to a point in Aries from January 1 to August 1. It will then take up a slow retrograde motion and end

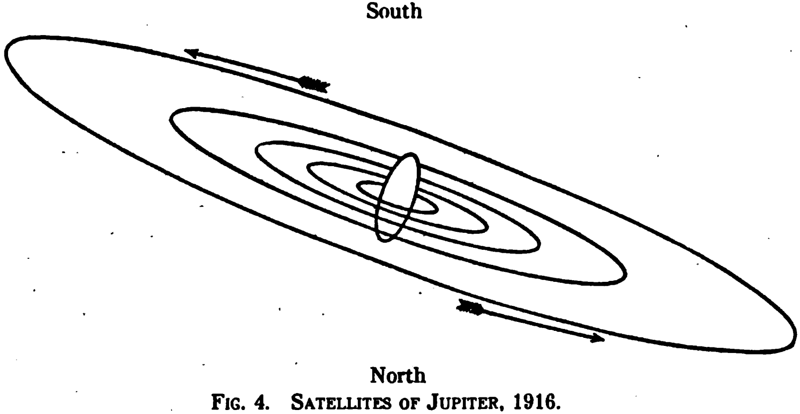


FIG. 4. SATELLITES OF JUPITER, 1916.
Apparent orbits of five of the satellites of Jupiter at date of opposition, October 23, 1916, as seen in an inverting telescope and elongated in the ratio of three to one in the direction of their minor axes.

the year near the eastern edge of Pisces. At the beginning of the year Jupiter will still be visible in the west at sunset. In March it will be lost in the rays of the sun and will be behind the sun from the earth on April 1. In May it will again appear in the morning sky. It will then rise earlier each morning and in the latter part of July it will rise at midnight. In October it will rise at sunset, and be visible in the early evening for the rest of the year.

Figure 4 shows the orbits of the satellites of Jupiter at the date of opposition, October 23.

Saturn will move first westward in Gemini, then eastward into Cancer, then westward again in Cancer during November and December. Saturn will be visible in the evening until the early part of the summer. During the summer it will be obscured by the sun. It will be behind the sun on July 12. About September 1 it will again appear in the morning sky. It will be most favorably situated for observation in the early part of the year, being at opposition on January 4. Figure 5 shows the orbits of the satellites of Saturn at this date.

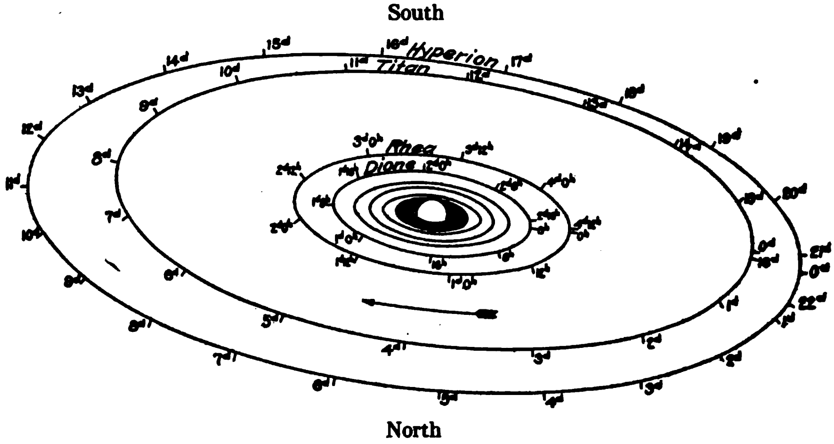


FIG 5. SATELLITES OF SATURN, 1916.
Apparent orbits of the seven inner satellites of Saturn at date of opposition, January 4, 1916, as seen in an inverting telescope.

Uranus moves back and forth as it did last year in the constellation Capricornus. It ends the year a little more than 4 degrees east of its starting point. Its real motion is toward the east, and its shifting position as seen in the figure is due to the earth's motion. Taking out of its total path its proper motion eastward, the remainder is due to parallax which is quite large in the case of Uranus and very small in the case of the distant stars. Uranus will be visible low in the west at sunset at the beginning of the year. It will then disappear in the rays of the sun and be back of the sun on February 5. In March it will again appear in the morning sky and be visible throughout the year. It will be best situated about August 10, being at opposition on this date. Figure 6 shows the orbits of its satellites at this date.

Neptune will have a motion similar to that described for Uranus. It however is in the constellation Cancer. It will be at opposition on January 22. During July and August it will not be visible because of the nearness of the sun. After this date it will again appear in the morning sky. Figure 7 shows the orbit of its satellite at the date of the opposition.

COMETS.

The comet 1913 *f* (Delavan) which has been visible, except when too near the sun, since its discovery will still be visible at the beginning of the year in the larger telescopes in the southern hemisphere. According to computation it will be of about the eleventh magnitude. Comet 1915 *a* (Mellish) also will be visible at the beginning of the year. It will be visible in the northern hemisphere. It will be moving northwestwardly in the constellation Taurus, about an hour west of Aldebaran. It will be of the tenth magnitude and decreasing rapidly in brightness because it is rapidly receding from the sun. Comet 1915 *e* (Taylor) may be found at the beginning of the year according to the diagram in the comet notes in this number.

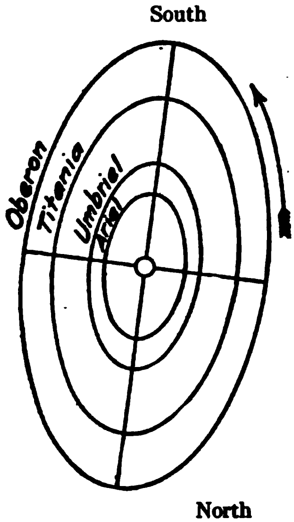


FIG. 6. SATELLITES OF URANUS, 1916. Apparent orbits of the satellites of Uranus at date of opposition, August 10, 1916 as seen in an inverting telescope.

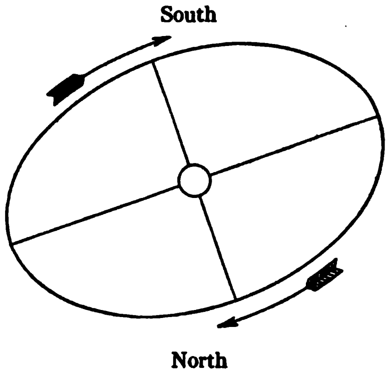


FIG. 7. SATELLITE OF NEPTUNE. 1916. Apparent orbit of the satellite of Neptune at date of opposition, January 22, 1916, as seen in an inverting telescope.

Of the periodic comets, five of those which have been seen only once and whose periods have been determined may possibly be seen again this year. Comet Barnard 1884 II is due at perihelion very early in 1917 and may be discovered in its approach during the latter part of 1916; Comet Perrine 1896 VII is due at perihelion, according to the period determined for it, about the middle of the year; Comet Giacobini 1896 V also is due to arrive at perihelion about the middle of the year; Comet Denning 1894 I is due to arrive at perihelion a little before the middle of the year; Comet 1909 *e* (Daniel) is due at perihelion sometime in April. Each of these comets as stated has been seen but once. The return predicted for this year is the sixth for Barnard's comet, the third for Perrine's, the third for Giacobini's, the third for Denning's and the first for Daniel's. The fact that they have escaped detection on several preceding returns to perihelion make it seem improbable that they will be seen at this time. It may be however that conditions this time will be more favorable than at the former returns.

METEORS.

The sight of a meteor, or falling star, always attracts the attention of the observer, and if it happens to be a particularly brilliant one it arouses in those unacquainted with the phenomenon a feeling of awe, almost that of fear. Unless one deliberately sets out to observe meteors only an occasional one will be seen by him, and he will get the impression that they are not very numerous and that they occur only at night. However there is a continual bombardment of the earth, usually the earth's atmosphere only, by these small masses from space. Only the brightest ones at night are apparent, and practically none of those that fall in the day time. There are certain times in the year when special displays may be expected. The table following indicates these times with the place in the sky from which the meteors seem to come, and the character of the apparition.

Date	Radiant		Character
	α	δ	
Jan. 2-3	230°	+53°	Swift; long paths.
Apr. 20-22	271	+33	Swift.
May 1-6	338	− 2	Swift; streaks.
July 28-30	339	−11	Slow; long.
Aug. 10-13	46	+57	Swift; streaks.
Oct. 18-20	92	+15	Swift; streaks.
Nov. 14-16	150	+22	Swift; streaks.
Nov. 17-23	25	+43	Very slow; trains.
Dec. 10-12	108	+33	Swift; short.

VARIABLE STARS.

The predicted times of the maxima of certain short period variables and of the minima of certain others will be published from month to month in advance as in former years. These times are computed from the best elements that are available and the periods and times are corrected as new information comes to hand concerning any of these variables. Only a few of these stars are visible to the naked eye, but even a small telescope will enable the user of it to follow practically all of these stars through their light changes.

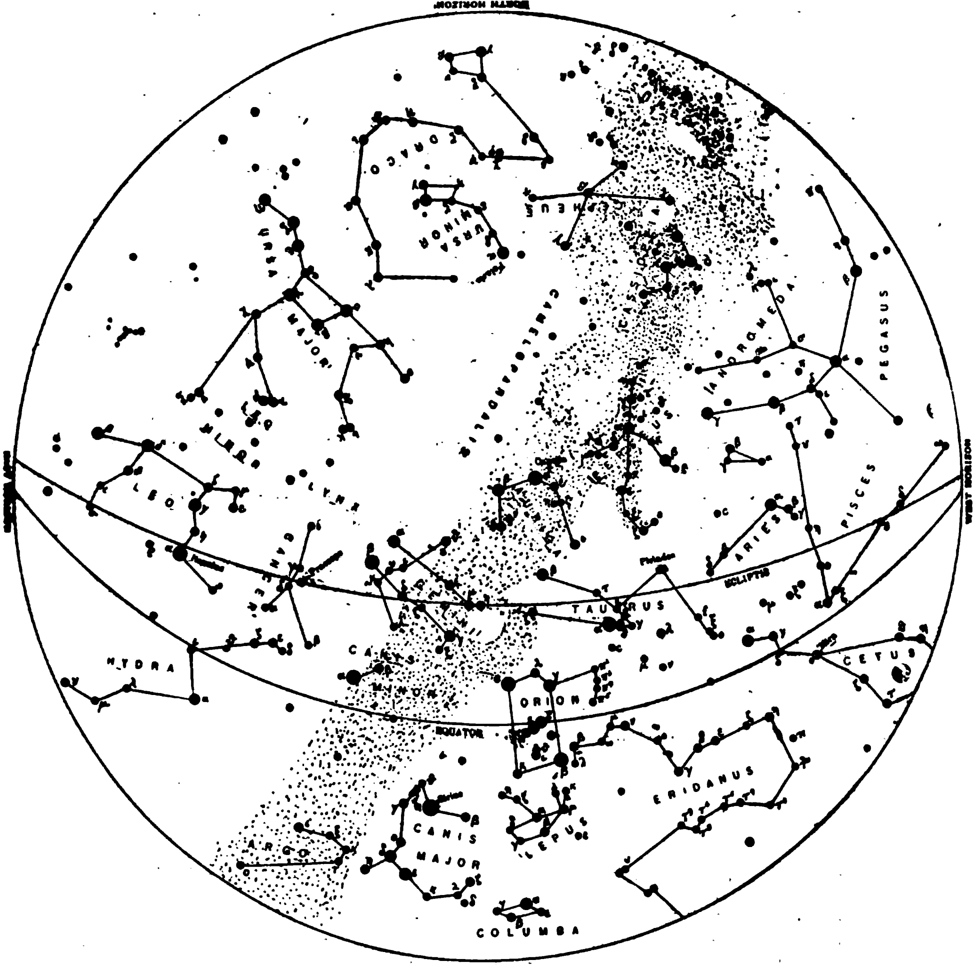
The times for this year have been computed at the Goodsell Observatory by Miss Agnes E. Wells, Miss Bertha Booth and Miss Bessie Burnham.

OCCULTATIONS.

For the convenience of our readers who may not have access to the *American Ephemeris* the list of stars as given in this volume whose occultations by the moon are visible at Washington will be published one month in advance. It will be an interesting exercise for the observers with a telescope, a small one is as good as a large one for this purpose, to observe these occultations to see how well the times have been determined. This is one way by which the movement of the moon has been determined with such great accuracy.

PLANET NOTES FOR FEBRUARY, 1916.

The sun will move in a northeasterly direction, passing from Capricornus into Aquarius during this month through a region in which there are no conspicuously bright stars.



THE CONSTELLATIONS AT 9:00 P. M. FEBRUARY 1.

The phases of the moon for this month are as follows:

New Moon	Feb. 3	at 10 A.M.	C.S.T.
First Quarter	10	" 4 P.M.	"
Full Moon	18	" 8 P.M.	"
Last Quarter	26	" 3 A.M.	"

The moon will come to perigee twice in this month, once on February 1, and again on February 29. It will be at apogee on February 13.

Mercury will continue to move from its position of greatest elongation east on January 20, westward toward the sun. It will be at a point of inferior conjunction with the sun on February 5. It will consequently be too close to the sun near this date to be visible. It will be very near a point of greatest elongation west at the close of the month. It will then be visible in the morning sky just before sunrise. It will rise about an hour and a half before the sun.

Venus will be the brilliant evening star during this month. It will be quite high in the sky at sunset. It will stand out brilliantly in a part of the sky which is free from bright stars. It will be more than ten times as bright as Aldebaran, a typical first magnitude star.

Mars will be in a very good position for observers. On February 9 it will be in opposition with the sun. Because it is considerably farther north than the sun it will rise before sunset and therefore will be well up in the sky for evening observation. It will approach the earth until February 9, and will then recede. It will not be very bright at this opposition since it will come only within about 60,000,000 miles of the earth.

Jupiter will be moving eastward much more slowly than the sun. It will therefore be lower in the west on each succeeding day. It will however continue to be visible throughout the month. Jupiter and Venus will be in the same part of the sky. Venus will pass Jupiter on February 13.

Saturn will continue throughout this month to be found in the constellation Gemini. As this is a winter constellation Saturn may be easily observed. It will be moving westward slowly during this month.

Uranus will be in conjunction with the sun on February 5. It will therefore be too close to the sun to be observed until very late in the month, and then it will be visible only in the early morning.

Neptune will be a few hours east of Saturn. It also will therefore be favorably situated. It will be moving slowly westward in the constellation Cancer.

Occultations Visible at Washington.

Date 1916	Star's Name	Magnitude	IMMERSION. Washington M.T.			EMERSION. Washington M.T.			Duration	
					Angle fm N.			Angle fm N.		
			h	m	°	h	m	°	h	m
Feb. 14	ε Geminorum	3.2	4	13	213	4	42	205	0	30
14	ω Geminorum	5.2	15	22	62	16	17	280	0	55
15	B.D. +23°1744	6.4	2	47	168	3	39	251	0	52
15	192 B Gemin.	6.3	8	54	179	10	14	260	1	19
17	π Cancri	5.6	4	52	165	5	51	280	0	59
21	q Virginis	5.3	12	34	202	13	26	261	0	52
27	69 G Sagittarii	6.3	15	2	109	15	56	303	0	54

Saturn's Satellites for February, 1916.

CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.

I. Mimas. Period $0^d\ 22^h.6$.

	d	h		h	d		d	h		d	h
Feb.	1	16.2 W	Feb.	8	17.8 E	Feb.	15	19.3 W	Feb.	23	19.7 E
	2	14.8 W		9	16.4 E		16	18.0 W		24	18.3 E
	3	13.4 W		10	15.0 E		17	16.6 W		25	10.9 E
	4	12.0 W		11	13.6 E		18	15.2 W		26	15.5 E
	5	10.6 W		12	12.2 E		19	13.9 W		27	14.2 E
	5	22.0 E		13	10.8 E		20	12.5 W		28	12.8 E
	6	20.6 E		13	22.1 W		21	11.1 W		29	11.4 E
	7	19.2 E		14	20.7 W		22	21.1 E			

II. Enceladus. Period $1^d\ 8.9^h$.

Feb.	1	12.5 E	Feb.	8	8.9 E	Feb.	15	5.4 E	Feb.	22	1.8 E
	2	21.4 E		9	17.8 E		16	14.2 E		23	10.7 E
	4	6.3 E		11	2.7 E		17	23.1 E		24	19.5 E
	5	15.2 E		12	11.6 E		19	8.0 E		26	4.4 E
	7	0.1 E		13	20.5 E		20	16.9 E		27	13.3 E
										28	22.2 E

III. Tethys. Period $1^d\ 21^h.3$.

Feb.	1	21.5 E	Feb.	9	10.7 E	Feb.	17	0.0 E	Feb.	24	13.2 E
	3	18.8 E		11	8.1 E		18	21.3 E		26	10.5 E
	5	16.1 E		13	5.4 E		20	18.6 E		28	7.8 E
	7	13.4 E		15	2.7 E		22	15.9 E			

IV. Dione. Period $2^d\ 17^h.7$.

Feb.	2	4.3 E	Feb.	10	9.3 E	Feb.	18	14.3 E	Feb.	26	19.3 E
	4	22.0 E		13	3.0 E		21	8.0 E		29	13.0 E
	7	15.7 E		15	20.6 E		24	3.7 E			

V. Rhea. $4^d\ 12^h.5$.

Feb.	4	10.3 E	Feb.	13	11.0 E	Feb.	22	11.8 E	Feb.	27	0.2 E
	8	22.7 E		18	23.4 E						

VI. Titan. Period $15^d\ 23^h.3$.

Feb.	6	12.8 E	Feb.	14	4.8 W	Feb.	22	10.8 E

VII. Hyperion. Period $21^d\ 7^h.6$.

Feb.	10	7.1 W	Feb.	19	23.0 E

VIII. Japetus. Period $79^d\ 22^h.1$.

Feb.	3	9.4 S	Feb.	23	21.6 E

IV. Phoebe. Period $523^d\ 15^h.6$·

		α Ph. — α Sat.		δ Ph. — δ Sat.				α Ph. — α Sat.		δ Ph. — δ Sat.	
		m	s	′	″			m	s	′	″
Feb.	2	+0	4.5	+3	14	Feb	16	−0	14.4	+3	11
	4	+0	1.8	3	14		11	0	17.1	3	10
	6	−0	0.9	3	14		20	0	19.8	3	9
	8	0	3.6	3	14		22	0	22.5	3	7
	10	0	6.3	3	13		24	0	25.2	3	6
	12	0	9.0	3	13		26	0	27.9	3	5
	14	−0	11.7	+3	12		28	0	30.6	3	3

VARIABLE STARS.

Approximate Magnitudes of Variable Stars of Long Period on Dec. 1, 1915.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.
X Androm.	0	10.8	+46	27	<14.0
T Androm.		17.2	+26	26	9.5*d*
T Cassiop.		17.8	+55	14	9.0 *i*
R Androm.		18.8	+38	1	13.8*d*
S Ceti		19.0	− 9	53	8.5*d*
Y Cephei		31.3	+79	48	9.8 *i*
U Cassiop.		40.8	+47	43	9.0*d*
RW Androm.		41.9	+32	8	13.8*d*
V Androm.		44.6	+35	6	9.7 *i*
RR Androm.		45.9	+33	50	10.9*d*
RV Cassiop		47.1	+46	53	11.3*d*
W Cassiop.		49.0	+58	1	11.5*d*
Z Ceti	1	1.6	− 2	1	13.1*d*
U Androm.		9.8	+40	11	10.6 *i*
S Cassiop.		12.3	+72	5	13.8*d*
S Piscium		12.4	+ 8	24	10.0 *i*
U Piscium		17.7	+12	21	12.3 *i*
RZ Persei		23.6	+50	20	13.0*d*
R Piscium		25.5	+ 2	22	9.1*d*
RU Androm.		32.8	+38	10	11.0*d*
Y Androm.		33.7	+38	50	10.9*d*
X Cassiop.		49.8	+58	46	11.8 *i*
U Persei		53.0	+54	20	8.6
S Arietis		59.3	+12	3	<14.0
R Arietis	2	10.4	+24	35	12.3*d*
W Androm.		11.2	+43	50	13.8
Z Cephei		12.8	+81	13	<14.0
o Ceti		14.3	− 3	26	4.0 *i*
S Persei		15.7	+58	8	9.0
R Ceti		20.9	− 0	38	11.0 *i*
RR Persei		21.7	+50	49	12.2*d*
U Ceti		28.9	−13	35	8.9*d*
RR Cephei		29.4	+80	42	13.8
R Trianguli		31.0	+33	50	10.0 *i*
W Persei		43.2	+56	34	10.3
U Arietis	3	5.5	+14	25	13.0 *i*
X Ceti		14.3	− 1	26	9.0*d*
Y Persei		20.9	+43	50	9.8
R Persei		23.7	+35	20	10.0*d*
Nov. Per. No. 2		24.4	+43	34	13.5*d*
W Tauri	4	22.2	+15	49	12.0 *i*
R Tauri		22.8	+ 9	56	13.8*d*
S Tauri		23.7	+ 9	44	<14.0
T Camelop.		30.4	+65	57	13.7*d*
X Camelop.		32.6	+74	56	9.0*d*
RX Tauri		32.8	+ 8	9	9.0
V Tauri		46.2	+17	22	10.3 *i*
R Orionis		53.6	+ 7	59	13.3
R Leporis		55.0	−14	57	7.0
T Leporis	5	0.6	−22	2	8.8 *i*
V Orionis		0.8	+ 3	58	12.4
R Aurigae	5	9.2	+53	28	14.0*d*
W Aurigae		20.1	+36	49	13.0*d*
S Aurigae		20.5	+34	4	9.3
S Orionis		24.1	− 4	46	8.4*d*
S Camelop.		30.2	+68	45	8.8*d*
T Orionis		30.9	− 5	32	10.0*d*
U Aurigae		35.6	+31	59	13.0
SU Tauri		43.2	+19	2	10.0
V Camelop.		49.4	+74	30	11.1 *i*
U Orionis		49.9	+20	10	10.4*d*
Z Aurigae		53.6	+53	18	9.0
X Aurigae	6	4.4	+50	15	8.9 *i*
SS Aurigae		5.8	+47	46	<14.0
V Aurigae		16.5	+47	45	9.0
V Monoc.		17.7	− 2	9	8.9 *i*
U Lyncis		31.8	+59	57	13.6*d*
S Lyncis		35.9	+58	0	10.1 *i*
Y Monoc.		51.3	+11	22	9.0 *i*
X Monoc.		52.4	− 8	56	7.8
R Lyncis		53.0	+55	28	13.0
R Geminorum	7	1.3	+22	52	7.8*d*
V Can. Min.		1.5	+ 9	2	10.0*d*
R Can. Min.		3.2	+10	11	10.0*d*
RR Monoc.		12.4	+ 1	17	<13.0
S Can. Min.		27.3	+ 8	32	8.0 *i*
Z Puppis		28.3	−20	27	13.0
T Can. Min.		28.4	+11	58	9.5
U Can. Min.		35.9	+ 8	37	9.5
S Geminorum		37.0	+23	41	13.5
T Geminorum		43.3	+23	59	9.2
U Puppis		56.1	−12	34	13.0
R Cancri	8	11.0	+12	2	11.3
V Cancri		16.0	+17	36	11.0 *i*
RT Hydrae		24.7	− 5	59	8.5
U Cancri		30.0	+19	14	10.8*d*
S Hydrae		48.4	+ 3	27	8.2 *i*
T Hydrae		50.8	− 8	46	8.0
T Cancri		51.0	+20	14	9.0
S Pyxidis	9	0.7	−24	41	11.0 *i*
W Cancri		4.0	+25	39	13.0
X Hydrae		30.7	−14	15	12.0
Y Draconis		31.1	+78	18	13.6*d*
R Leo. Min.		39.6	+34	58	9.8 *i*
RR Hydrae		40.4	−23	34	<13.5
R Leonis		42.2	+11	54	5.5
Y Hydrae		46.4	−22	33	6.8
V Leonis		54.5	+21	44	8.8
R Urs. Maj.	10	37.6	+69	18	7.7
V Hydrae		46.8	−20	43	7.5
W Leonis		48.4	+14	15	10.8
S Leonis	11	5.7	+ 6	0	10.8 *i*

Approximate Magnitudes of Variable Stars of Long Period on Dec. 1, 1915—Continued.

Name.	R. A. 1900.		Decl. 1900		Magn.	Name.	R. A. 1900.		Decl. 1900		Magn.
	h	m	°	′			h	m	°	′	
R Com. Ber.	11	59.1	+19	20	14.0*d*	U Lyrae	19	16.6	+37	42	12.7*d*
T Urs. Maj.	12	31.8	+60	2	9.6*d*	TY Cygni		29.8	+28	6	13.7
RS Urs. Maj.		34.4	+59	2	10.6 *i*	RT Aquilae		33.3	+11	30	14.0
S Urs. Maj.		39.6	+61	38	8.8 *i*	R Cygni		34.1	+49	58	11.8*d*
T Urs. Min.	13	32.6	+73	56	10.8*d*	RV Aquilae		35.9	+ 9	42	12.6*d*
R Can. Ven.		44.6	+40	2	8.8 *i*	RT Cygni		40.8	+48	32	8.8*d*
U Urs. Min.	14	15.1	+67	15	8.1	TU Cygni		43.3	+48	49	9.7*d*
S Bootis		19.5	+54	16	10.2*d*	X Aquilae		46.5	+ 4	13	13.8
R Camelop.		25.1	+84	17	11.8*d*	χ Cygni		46.7	+32	40	9.6 *i*
V Bootis		25.7	+39	18	7.6	RR Aquilae		52.4	− 2	11	9.0
S Urs. Min.	15	33.4	+78	58	12.2	RS Aquilae		53.7	− 8	9	9.8
R Cor.Bor.		44.4	+28	28	6.0	Z Cygni		58.6	+49	46	9.8 *i*
X Cor. Bor.		45.2	+36	35	9.6	SY Aquilae	20	2.3	+12	39	13.0
V Cor. Bor.		46.0	+39	52	8.2	S Cygni		3.4	+57	42	12.7 *i*
W Cor. Bor.	16	11.8	+38	3	8.2 *i*	R Capricorni		5.7	−14	34	12.6*d*
U Herculis		21.4	+19	7	12.0*d*	S Aquilae		7.0	+15	19	9.4 *i*
R Urs. Min.		31.3	+72	28	9.8	RU Aquilae		8.0	+12	42	10.5*d*
W Herculis		31.7	+37	32	13.5*d*	W Capricorni		8.6	−22	17	13.5*d*
R Draconis		32.4	+66	58	11.7*d*	RS Cygni		9.8	+38	28	7.6
RV Herculis		56.8	+31	22	<14.0	Z Aquilae		9.8	− 6	27	10.1 *i*
RT Herculis	17	6.8	+27	11	13.6*d*	R Delphini		10.1	+ 8	47	13.2
RS Herculis		17.5	+23	1	9.6*d*	RT Capricorni		11.3	−21	38	7.5
RU Ophiuchi		28.1	+ 9	30	9.0	SX Cygni		11.6	+30	46	14.0
RT Ophiuchi		51.8	+11	11	<13.5	U Cygni		16.5	+47	35	7.3
T Draconis		54.8	+58	14	10.2	RU Capricorni		26.7	−22	2	10.0
RY Herculis		55.4	+19	29	11.0 *i*	Z Delphini		28.1	+17	7	13.0*d*
V Draconis		56.3	+54	53	9.8*d*	ST Cygni		29.9	+54	38	11.0*d*
T Herculis	18	5.3	+31	0	10.6 *i*	Y Delphini		36.9	+11	31	13.3*d*
W Draconis		5.4	+65	56	9.5 *i*	V Cygni		38.1	+47	47	8.5
X Draconis		6.8	+66	8	10.6 *i*	S Delphini		38.5	+16	44	10.1 *i*
W Lyrae		11.5	+36	38	11.7 *i*	Y Aquarii		39.2	− 5	12	<13.0
RY Ophiuchi		11.6	+ 3	40	8.5	T Delphini		40.7	+16	2	13.4*d*
SV Herculis		22.3	+24	58	10.1*d*	W Aquarii		41.2	− 4	27	13.0
T Serpentis		23.9	+ 6	14	<13.5	U Capricorni		42.6	−15	9	13.8
SV Draconis		31.2	+49	18	13.8	V Delphini		43.2	+18	58	10.2*d*
RZ Herculis		32.7	+25	58	11.5*d*	T Aquarii		44.7	− 5	31	11.1*d*
X Ophiuchi		33.6	+ 8	44	8.0	RZ Cygni		48.5	+46	59	11.8*d*
RY Lyrae		41.2	+34	34	13.2 *i*	X Delphini		50.3	+17	16	13.1*d*
RW Lyrae		42.1	+43	32	11.8	R Vulpeculae		59.9	+23	26	9.0 *i*
R Scuti		42.2	− 5	49	5.0	TW Cygni	21	1.8	+29	0	13.8*d*
RX Lyrae		50.4	+32	42	<13.5	V Capricorni		1.8	−24	19	9.0 *i*
ST Sagittarii		55.9	−12	54	13.0*d*	X Capricorni		2.8	−21	45	<13.5
Z Lyrae		56.0	+34	49	<13.5	X Cephei		3.6	+82	40	10.6*d*
RT Lyrae		57.8	+37	22	12.5 *i*	Z Capricorni		5.0	−16	35	12.5*d*
R Aquilae	19	1.6	+ 8	5	8.2*d*	RS Aquarii		5.8	− 4	27	13.0 *i*
V Lyrae		5.2	+29	30	<13.5	T Cephei		8.2	+68	5	6.4 *i*
RW Sagittarii		8.1	−19	2	12.0*d*	R Equulei		8.4	+12	23	11.8*d*
RX Sagittarii		8.7	−18	59	9.9	RR Aquarii		9.8	− 3	19	12.0*d*
RU Lyrae		9.1	+41	8	8.0	X Pegasi		16.3	+14	2	14.0*d*
S Lyrae		9.1	+25	50	<14.0	T Capricorni		16.5	−15	35	13.5
RS Lyrae		9.3	+33	15	13.0	Y Capricorni		28.9	−14	25	12.0 *i*
U Draconis		9.9	+67	7	11.7 *i*	S Cephei		36.5	+78	10	10.2 *i*
W Aquilae		10.0	− 7	13	<14.0	RU Cygni		37.3	+53	52	8.0
T Sagittarii		10.5	−17	9	9.6 *i*	SS Cygni		38.8	+43	8	12.0
R Sagittarii		10.8	−19	29	7.4*d*	RR Pegasi		40.0	+24	33	14.2*d*
TZ Cygni		13.4	+50	0	10.4	V Pegasi		56.0	+ 5	38	<13.5
S Sagittarii		13.6	−19	12	9.6 *i*	RT Pegasi		59.8	+34	38	9.6 *i*
Z Sagittarii		13.8	−21	7	13.0*d*	T Pegasi	22	4.0	+12	3	<13.5

Approximate Magnitudes of Variable Stars of Long Period on Dec. 1, 1915—Continued.

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900.	Decl. 1900.	Magn.
	h m	° ′			h m	° ′	
Y Pegasi	22 6.8	+13 52	<14.0	Z Androm.	23 28.8	+48 16	11.0
RS Pegasi	7.4	+14 4	9.0 *i*	ST Androm.	33.8	+35 13	10.8*d*
RV Pegasi	21.0	+29 58	12.8 *i*	R Aquarii	38.6	−15 50	9.0*d*
S Lacertae	24.6	+39 48	11.8*d*	Z Cassiop.	39.7	+56 2	14.0
R Lacertae	38.8	+41 51	8.4 *i*	RR Cassiop.	50.7	+53 8	12.2
S Aquarii	51.8	−20 53	8.3 *i*	V Ceti	52.8	− 9 31	11.8 *i*
RW Pegasi	59.2	+14 46	10.8 *i*	R Cassiop.	53.3	+50 50	7.0
R Pegasi	23 1.6	+10 0	7.3 *i*	Z Pegasi	55.0	+25 21	9.7
V Cassiop.	7.4	+59 8	8.8*d*	Y Cassiop	58.2	+55 7	14.0
W Pegasi	14.8	+25 44	12.8*d*	SV Androm.	59.2	+39 33	12.7*d*
S Pegasi	15.5	+ 8 22	13.2*d*				

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—H. C. Bancroft, Jr., T. C. H. Bouton, A. B. Burbeck, L. Campbell, H. O. Eaton, G. L. Harrell, W. P. Hoge, S. C. Hunter, O. Mach, C. Y. McAteer, C. S. Mundt, G. F. Nolte, W. T. Olcott, D. B. Pickering, C. F. Richter, F. H. Spinney, H. M. Swartz, I. E. Woods, and A. S. Young.

Maxima of Variable Stars of Short Period.

[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1916. February
	h m	° ′		d h	d h d h d h d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7	16 13
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	4 22; 13 2; 21 5; 29 8
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	5 5; 12 23; 20 17; 28 11
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	1 17; 16 12
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	7 4; 15 2; 23 1
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	6 18; 14 13; 22 8
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	8 6; 15 13; 22 20
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	3 0; 19 0
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	6 1; 14 15; 23 5
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	8 7; 19 10
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	2 14; 14 5; 25 20
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	7 8; 15 0; 22 16
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	10 22; 21 1
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	6 10; 14 3; 21 21; 29 14
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	6 5; 17 6; 22 19; 28 7
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	6 5; 13 19; 21 9; 28 22
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	3 17
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	7 16; 14 21; 22 2; 29 7
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	3 9; 11 7; 19 5; 27 3
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	1 23; 11 3; 21 7

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. February							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
RU Camelop.	7	10.9	+69	51	8.5— 9.8	22	06.5			22	0				
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	5	10;	13	9;	21	8;	29	6
V Carinae	8	26.7	−59	47	7.4— 8.1	6	16.7	4	9;	11	2;	17	19;	24	11
T Velorum	8	34.4	−47	01	7.6— 8.5	4	15.3	2	0;	11	7;	20	14;	29	20
V Velorum	9	19.2	−55	32	7.5— 8.2	4	08.9	2	3;	10	21;	19	15;	28	9
Z Leonis	9	46.4	+27	22	7.9— 9.6	59	0.0								
RR Leonis	10	02.1	+24	29	9.1—10.1	0	10.9	3	22;	10	16;	17	11;	24	6
SU Draconis	11	32.2	+67	53	8.9— 9.6	0	15.8	5	2;	11	17;	18	7;	24	22
S Muscae	12	07.4	−69	36	6.4— 7.3	9	15.8	6	15;	16	7;	25	23		
SW Draconis		12.8	+70	04	8.8— 9.6	0	13.7	7	21;	15	20;	23	20		
T Crucis		15.9	−61	44	6.8— 7.6	6	17.6	4	19;	11	13;	18	6;	25	0
R Crucis		18.1	−61	04	6.8— 7.9	5	19.8	4	20;	10	16;	22	8;	28	3
S Crucis	12	48.4	−57	53	6.5— 7.6	4	16.6	4	16;	14	1;	23	10;	28	3
W Virginis	13	20.9	− 2	52	8.7—10.4	17	06.5			18	0				
SS Hydrae		25.0	−23	08	7.4— 8.1	8	4.8	2	14;	10	19;	19	0;	27	5
RV Urs. Maj.	13	29.4	+54	31	9.2— 9.9	0	11.2	7	11;	14	12;	21	12;	28	13
ST Virginis	14	22.5	− 0	27	10.3—11.4	0	09.9	8	1;	16	6;	24	11		
V Centauri		25.4	−56	27	6.4— 7.8	5	11.9	4	13;	10	1;	21	1;	26	12
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	5	12;	13	1;	20	14;	28	3
RU Bootis	14	41.5	+23	44	12.8—14.3	0	11.9	3	16;	11	2;	18	12;	25	22
R Triang. Austr.	15	10.8	−66	08	6.7— 7.4	3	09.3	4	18;	11	13;	18	7;	25	2
S Triang. Austr.	15	52.2	−63	29	6.4— 7.4	6	07.8	3	14;	9	21;	22	13;	28	21
S Normae	16	10.6	−57	39	6.6— 7.6	9	18.1	6	12;	16	6;	25	23		
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	3	15;	12	12;	21	8		
RV Scorpii	16	51.8	−33	27	6.7— 7.4	6	01.5	6	7;	12	9;	18	10;	24	12
X Sagittarii	17	41.3	−27	48	4.4— 5.0	7	00.3	1	20;	8	20;	22	21;	29	21
Y Ophiuchi		47.3	− 6	07	6.1— 6.5	17	02.9	7	7;	24	10				
W Sagittarii	17	58.6	−29	35	4.3— 5.1	7	14.3	7	20;	15	10;	23	0		
Y Sagittarii	18	15.5	−18	54	5.4— 6.2	5	18.6	2	7;	8	2;	19	15;	25	10
U Sagittarii		26.0	−19	12	6.5— 7.3	6	17.9	3	10;	10	4;	16	22;	23	16
Y Scuti		32.6	− 8	27	8.7— 9.2	10	08.3	7	0;	17	8;	27	16		
Y Lyrae		34.2	+43	52	11.3—12.3	0	12.1	5	19;	11	19;	23	21;	29	22
RZ Lyrae		39.9	+32	42	9.9—11.2	0	12.3	4	5;	10	8;	22	15;	28	18
RT Scuti		44.1	−10	30	9.1— 9.7	0	11.9	5	5;	11	3;	17	2;	29	0
κ Pavonis	18	46.6	−67	22	3.8— 5.2	9	02.2	8	13;	17	15;	26	17		
U Aquilae	19	24.0	− 7	15	6.2— 6.9	7	00.6	1	19;	8	20;	22	21;	29	21
XZ Cygni		30.4	+56	10	8.6— 9.3	0	11.2	2	6;	9	6;	16	6;	23	6
U Vulpec.		32.2	+20	07	6.5— 7.6	7	23.5	1	12;	9	12;	17	11;	25	11
SU Cygni		40.8	+29	01	6.2— 7.0	3	20.3	7	21;	15	14;	23	6		
η Aquilae		47.4	+ 0	45	3.7— 4.5	7	04.2	4	10;	11	15;	18	19;	25	23
S Sagittae		51.5	+16	22	5.6— 6.4	8	09.2	1	23;	10	8;	18	17;	27	3
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	1	7:	7	15;	20	6;	26	14
X Cygni	20	39.5	+35	14	6.0— 7.0	16	09.3			12	18;	29	3		
T Vulpec.		47.2	+27	52	5.5— 6.1	4	10.5	3	23;	12	20;	21	17;	26	3
WY Cygni		52.3	+30	03	9.6—10.4	0	13.5	5	16;	12	10;	19	3;	25	20
RV Capric.		55.9	−15	37	9.2—10.1	0	10.7	5	1;	11	18;	18	12;	25	5
TX Cygni	20	56.4	+42	12	8.5— 9.7	14	17.4			7	3;	21	21		
VY Cygni	21	00.4	+39	34	8.8— 9.5	7	20.6	3	21;	11	18;	19	14;	27	11
SW Aquarii		10.2	— 0	20	9.9—10.8	0	11.0	4	23;	11	20;	18	17;	25	15
VZ Cygni	21	47.7	+42	40	8.2— 9.2	4	20.7	5	10;	14	22;	24	16;	29	13
Y Lacertae	22	05.2	+50	33	9.1— 9.6	4	07.8	9	2;	17	17;	26	9		
δ Cephei		25.5	+57	54	3.7— 4.6	5	08.8	5	20;	11	5;	21	23;	27	8
Z Lacertae		36.9	+56	18	8.2— 9.0	10	21.1	7	16;	18	13;	29	11		
RR Lacertae		37.5	+55	55	8.5— 9.2	6	10.1	4	18;	11	4;	17	14;	24	0
V Lacertae	22	44.5	+55	48	8.5— 9.5	4	23.6	3	2;	13	1;	23	0;	27	23
SW Cassiop.	23	03.7	+58	11	9.2— 9.7	5	10.6	5	3;	10	13;	21	11;	26	21
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	2	14;	8	21;	21	11;	27	18
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4	6	7;	18	11				
V Cephei	23	51.7	+82	38	6.0—7.0	0	23.6	2	16;	7	16;	17	15;	27	15

Minima of Variable Stars of Short Period.

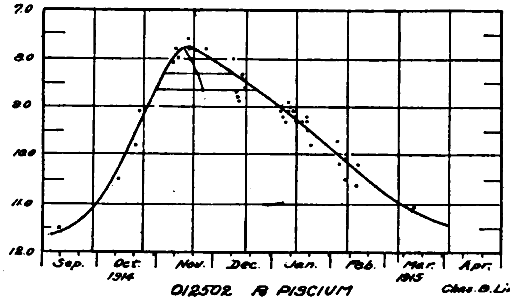
[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 February							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.8	9	6						
RT Sculptor.		31.5	−26	13	9.6—10.5	0	12.3	1	20;	9	12;	17	5;	24	21
UU Androm.		38.5	+30	24	10.7—11.9	1	11.7	3	11;	10	21;	18	7;	25	18
U Cephei	0	53.4	+81	20	7.0— 9.0	2	11.8	6	16;	14	3;	21	15;	29	2
Z Persei	2	33.7	+41	46	9.4—12	3	01.4	6	1;	12	4;	18	6;	24	9
TW Cassiop.		37.6	+65	19	8.2— 9.0	1	10.3	3	17;	10	21;	18	0;	25	4
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	6	9;	13	6;	20	3;	26	23
RZ Cassiop.		39.9	+69	13	6.9— 8.1	1	04.7	6	13;	13	17;	20	21;	28	1
TX Cassiop.		44.4	+62	22	9.4—10.1	2	22.2	2	11;	11	6;	20	0;	28	20
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	8	22;	16	21;	24	19		
RX Cassiop.	2	58.8	+67	11	8.6— 9.1	32	07.6			10	6				
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	5	12;	11	6;	22	16;	28	9
RT Persei		16.7	+46	12	9.5—11.5	0	20.4	6	1;	12	20;	19	15;	26	11
λ Tauri		55.1	+12	12	3.3— 4.2	3	22.9	4	2;	11	23;	19	21;	27	19
RW Tauri	3	57.8	+27	51	7.1—<11	2	18.5	3	16;	11	23;	20	7;	28	14
RV Persei	4	04.2	+33	59	9.5—11.0	1	23.4	1	3;	9	0;	16	22;	24	19
RW Persei		13.3	+42	04	8.8—11.0	15	04.8	8	10;	21	15				
SZ Tauri		31.4	+18	20	7.2— 7.7	3	03.6	5	16;	15	3;	24	13		
RS Cephei	4	48.6	+80	06	9.5—12.0	12	10.1	9	18;	22	4				
TT Aurigae	5	02.8	+39	27	7.8— 8.7	0	16.0	4	10;	11	2;	17	18;	24	10
RY Aurigae		11.5	+38	13	10.7—11.7	2	17.5	4	23;	10	10;	21	8;	26	19
RZ Aurigae		42.9	+31	40	10.6—13.3	3	00.3	6	12;	12	12;	18	13;	24	13
SV Tauri		45.8	+28	05	9.4—11.0	2	04.0	8	6;	16	22;	25	14		
Z Orionis		50.2	+13	40	9.7—10.7	5	04.9	4	2;	14	12;	24	22		
SV Gemin.		54.6	+24	28	9.8—<11	4	00.2	4	9;	12	9;	20	9;	28	9
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	1	23;	7	16;	18	3;	24	21
U Columbae	6	11.2	−33	03	9.2—10.0	2	19.2	4	5;	9	19;	21	0;	26	15
SX Gemin.		22.0	+20	37	10.8—11.5	1	08.8	4	12;	12	16;	20	21;	29	2
RW Monoc.		29.3	+ 8	54	9.0—10.8	1	21.7	4	2;	11	17;	19	8;	26	23
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0	6	0;	18	5				
RU Monoc.	6	49.4	− 7	28	9.8—10.5	0	21.5	4	23;	12	3;	19	7;	26	11
R Can. Maj.	7	14.9	−16	12	5.8— 6.4	1	03.3	7	12;	16	14;	25	16		
RY Gemin.		21.7	+15	52	8.9—<10	9	07.2	4	12;	13	19;	23	2		
Y Camelop.		27.6	+76	17	9.5—12	3	07.3	3	19;	13	17;	23	15		
TX Gemin.		30.3	+17	8	10.0—11.9	2	19.2	4	10;	12	19;	21	5;	29	14
RR Puppis		43.5	−41	08	9.4—10.7	6	10.3	5	0;	11	10;	17	21;	24	7
V Puppis	7	55.4	−48	58	4.1— 4.8	1	10.9	3	7;	10	14;	17	20;	25	3
X Carinae	8	29.1	−58	53	7.9— 8.7	0	13.0	5	20;	13	23;	22	2		
S Cancri	8	38.2	+19	24	8.2—10	9	11.6	5	7;	14	18;	24	6		
RX Hydrae	9	00.8	− 7	52	9.1—10.5	2	6.8	7	1;	16	4;	25	7		
S Antliae		27.9	−28	11	6.7— 7.3	0	07.8	6	24;	13	11;	19	23;	26	11
S Velorum		29.4	−44	46	7.8— 9.3	5	22.4	1	10;	7	8;	19	5;	25	3
Y Leonis	9	31.1	+26	41	9.3—11.2	1	16.5	1	18;	10	4;	18	14;	27	1
RR Velorum	10	17.8	−41	36	10.0—10.9	1	20.5	5	19;	15	1;	24	8		
SS Carinae	10	54.2	−61	23	12.2—12.8	3	07.2	6	15;	13	6;	19	20;	26	11
ST Urs. Maj.	11	22.4	+45	44	6.7— 7.2	8	19.2	1	10;	10	5;	19	0;	27	19
RW Urs. Maj.		35.4	+52	34	10.3—11.4	7	07.9	6	2;	13	10;	20	17;	28	1
Z Draconis	11	39.8	+72	49	9.9—13.6	1	08.6	5	21;	12	15;	19	10;	26	5
RZ Centauri	12	55.6	−64	05	8.5— 8.9	1	21.0	5	6;	12	18;	20	6;	27	18
RS Can. Ven.	13	06.3	+36	28	7.5—12.5	4	19.2	8	0;	17	14;	27	4		
SS Centauri	13	07.2	−63	37	8.8—10.4	2	11.5	5	6;	12	16;	20	3;	27	13
δ Librae	14	55.6	− 8	07	4.8— 6.2	2	07.9	3	8;	10	8;	17	8;	24	7

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times o minima in 19 February							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
U Coronae	15	14.1	+32	01	7.6— 8.7	3	10.9	3	13;	10	11;	17	8;		6
TW Draconis		32.4	+64	14	7.3— 8.9	2	19.4	7	22;	16	8;	24	18		
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	8	9;	16	1;	23	16		
SW Ophiuchi	16	11.1	— 6	44	9.2—10.0	2	10.7	6	17;	14	1;	21	9;	28	17
SX Ophiuchi		12.6	— 6	25	10.5—11.2	2	01.5	1	22;	10	4;	18	10;	26	17
R Arae		31.1	—56	48	6.8— 7.9	4	10.2	7	20;	16	17;	25	13		
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1	9	21;	19	13				
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	2	19;	9	14;	23	5;	30	0
U Ophiuchi		11.5	+ 1	19	6.0— 6.7	0	20.1	2	15;	11	1;	19	10;	27	19
u Herculis		13.6	+33	12	4.6— 5.4	2	01.2	2	21;	9	1;	21	8;	27	12
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	5	12;	12	17;	19	22;	27	3
RV Ophiuchi		29.8	+ 7	19	9. —12	3	16.5	2	15;	10	0;	17	9;	24	18
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	6	10;	14	14;	22	18		
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	5	8;	12	21;	20	10;	27	23
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	6	6;	13	23;	21	17;	29	11
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	6	4;	14	4;	22	4		
WX Sagittae		53.6	—17	24	9.2—10.8	2	03.1	7	15;	16	4;	24	16		
WY Sagittae	17	54.9	—23	1	9.5—10.6	4	16.0	6	14;	15	22;	25	6;		
SX Draconis	18	03.0	+ 58	23	9.3—10.5	5	04.1	1	19;	12	4;	22	12		
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	6	12;	13	18;	21	0;	28	6
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	7	21;	14	18;	21	16;	28	14
RZ Scuti		21.1	— 9	15	7.4— 8.3	15	03.2	1	9;	16	12				
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	3	0;	11	6;	19	13;	27	19
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	4	6;	13	4;	22	1		
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	3	15;	11	22;	20	5;	28	13
RR Draconis		40.8	+62	34	9.3—13	2	19.9	5	12;	13	23;	22	10		
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	4	12;	11	3;	17	19;	24	10
β Lyrae		46.4	+33	15	3.4— 4.1	12	21.8	1	15;	14	13;	27	11		
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9			10	0;	19	13;	29	2
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	2	21;	10	11;	18	0;	25	14
RV Lyrae		12.5	+32	15	11. —12.8	3	14.4			11	13;	18	18;	25	23
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	7	20;	16	19;	25	18		
U Sagittae		14.4	+19	26	6.5— 9.0	3	09.1	5	19;	12	13;	19	7;	26	2
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	8	7;	15	16;	23	0		
TT Lyrae		24.3	+41	30	9.3—11.6	5	05.8	3	5;	13	16;	24	4;	29	10
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	6	2;	12	14;	19	3;	25	16
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	3	9;	10	9;	22	9;	28	10
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	2	5;	9	20;	16	11;	24	2
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	3	11;	12	15;	21	18		
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	7	0;	15	10;	23	21		
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	4	18;	11	13;	18	7;	25	2
UW Cygni		19.6	+42	55	10.5—13	3	10.8	7	9;	14	7;	21	4;	28	2
V Vulpec.		32.3	+26	15	8.2—9.8	37	19.0			14	10;				
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	9	22;	19	13;	29	4		
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	4	0;	13	4;	22	9		
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	7	16;	15	4;	22	15		
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	4	2;	9	22;	21	15;	27	11
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	9	11;	19	13;	29	16		
VV Cygni	21	02.3	+45	23	12.1—13.8	1	11.4	2	18;	10	3;	17	12;	24	21
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	5	7;	15	0;	24	16		
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	3	2;	10	22;	18	19;	26	16
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3			14	22				
RT Lacertae	21	57.4	+43	24	9.1—10.5	5	01.7	1	13;	11	17;	21	20		
RW Lacertae	22	40.6	+49	08	10.2—11.2	5	04.4	3	6;	13	14;	24	0;	29	4
X Lacertae	22	45.0	+55	54	8.2— 8.6	5	10.6	2	0;	12	21;	23	18;	29	5
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.3	4	15;	12	23;	21	6;	29	14
Y Piscium		29.3	+ 7	22	9.0—12.0	3	18.4	3	9;	11	21;	19	10;	26	23
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	2	9;	10	15;	18	21;	27	3

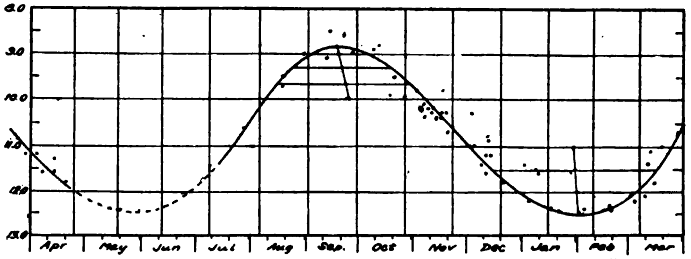


012502 R PISCIUM

Chas. B. Lindsley

Maximum Nov. 14, 1914 (7.8)

Observations by Amer. Assn. of Var. Star Obs.

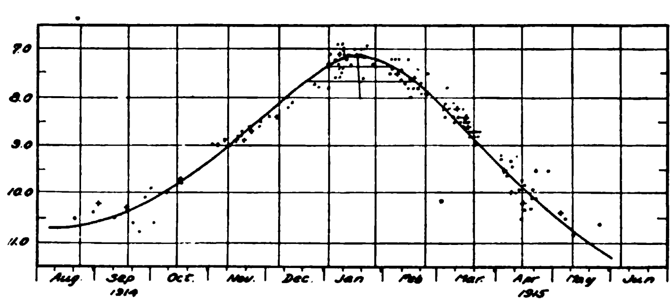


042215 W TAURI

Maximum Sept 13, 1914, (8.8), minimum Feb. 16, 1915 (12.5)

Observations by A.A of V S O

Chas B. Lindsley



072708 S CANIS MINORIS

Maximum Jan. 17, 1915, mag. 7.1

Observations by Amer. Assn of Var. Star Observers.

Chas. B. Lindsley

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Nov.-Dec., 1915.

We welcome as new members of the Association this month.

Mr. Charles L. Whitehorn, "Wh" Bloomfield, N. J. and
Dr. Edward F. Bigelow, "Bi" Sound Beach, Conn.

The latter observes with a 6″ refractor and should be able to do valuable work with it in observing the faint variables.

Mr. Bancroft leads this month in the number of observations contributed. His list contained 157 observations of 102 variables, a fine record. In this extension of the work, to cover many variables each month, a higher degree of efficiency is attained. Two observations a month of a large number of different stars are much more desirable than frequent observations of a few selected variables.

The secretary observed the asteroid "Cleopatra" on the field of the variable 045307 R Orionis on the night of December 3. Photographs promptly taken at the H. C. O. revealed the identity of the object. For the benefit of those who may have a like experience, the following advice may be of service: The first step is to ascertain if the unidentified object is in motion. This is done by noting a change in the configuration of the star field, or by taking transits of the object and of an adjacent star over a wire placed in the field. If no motion is detected the object is doubtless a nova or a variable, and the nearest observatory should be notified immediately. In this case, although the observation was disappointing to a certain degree, it lends zest to the work in which we are engaged, and shows that we must be ever on the alert.

The event of the month in the life of the Association was the meeting in Boston, Mass., November 20, 21, a red letter occasion for all of our members who participated.

At the invitation of Professor E. C. Pickering, Director of the Harvard College Observatory, the members met at the Observatory on the evening of November 20, where we were cordially welcomed by the Director, Professor Bailey, Mr. Leon Campbell, and Miss Woods.

Professor Bailey described the work on the cluster variables on which he is engaged, and Mr. Campbell escorted us about the Observatory, explaining the details of the variable star records which he faithfully keeps, and the interesting instrumental equipment of the observatory. Ample opportunity was offered for observing with the historic 15″ equatorial and the 12″ coudé. Many interesting objects were observed, and the evening was thoroughly enjoyed.

On the afternoon of the 21st we were again invited to the Observatory, a group picture was taken, and the members had the pleasure of meeting Miss Annie J. Cannon, who explained most interestingly the great work of the classification of stellar spectra in which she is engaged. We also enjoyed seeing the splendid set of illuminated plates on exhibition at the Observatory, and many other features of interest.

Later, the party adjourned to the Copley Square Hotel where a banquet was served. Professor Pickering and Mr. Campbell were our guests, and the evening was enjoyably spent in discussing our work in general, and plans were perfected for increasing the efficiency of our service.

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1915.

001032
S Sculptoris

Mo.	Day	Est.	Obs.
11	3	9.7	Ba
	10	9.5	R
	11	9.5	Ba
	22	8.8	Ba

001726
T Androm.

Mo.	Day	Est.	Obs.
11	2	8.8	O
	6	9.2	Pi
	7	8.8	O
	8	8.5	Ly
	10	8.9	R
	12	8.7	Ly
	22	8.8	Ba
	25	9.2	O
	25	9.3	Bu
	28	9.3	Sp
	28	9.3	O
	30	9.7	S
12	5	9.6	O

001755
T Cassiop.

Mo.	Day	Est.	Obs.
11	2	9.6	Bu
	6	10.2	Pi
	7	10.5	Sp
	28	8.7	Sp
	30	9.2	O

001838
R Androm.

Mo.	Day	Est.	Obs.
11	6	12.9	Hu

001909
S Ceti

Mo.	Day	Est.	Obs.
11	10	8.1	R
	22	8.0	Ba
	25	8.4	Bu
	28	8.3	Sp
	29	8.5	Pi
	30	8.5	O
12	2	8.5	S
	3	8.5	O
	3	8.5	Cr
	7	8.5	O

002614
T Piscium

Mo.	Day	Est.	Obs.
11	12	9.4	M

003179
Y Cephei

Mo.	Day	Est.	Obs.
11	7	11.6	Hu
	22	10.0	Ba
	27	10.1	Pi

004047
U Cassiop.

Mo.	Day	Est.	Obs.
11	2	8.5	Bu
	6	8.4	Pi
	10	7.9	R
	27	8.4	Ba
	30	9.5	S

004435
V Androm.

Mo.	Day	Est.	Obs.
11	2	11.0	O
	6	10.5	Pi
	6	10.9	Hu
	7	10.7	O
	22	9.4	Ba
	25	10.0	Bu
	25	9.8	O
	28	9.7	O
12	5	9.5	O

004533
RR Androm.

Mo.	Day	Est.	Obs.
11	2	9.8	O
	6	10.2	Hu
	7	9.6	O
	22	10.5	Ba
	25	10.8	O
	25	8.7	Bu

004746
RV Cassiop.

Mo.	Day	Est.	Obs.
11	2	9.3	Bu
	6	9.9	Pi
	27	11.1	Ba

004958
W Cassiop.

Mo.	Day	Est.	Obs.
11	2	11.0	Bu
	7	11.9	Nt
	27	11.2	Ba
	28	11.6	Sp

010102
Z Ceti

Mo.	Day	Est.	Obs.
11	7	12.0	Ho
	26	13.0	Ba

010940
U Androm.

Mo.	Day	Est.	Obs.
11	26	10.7	Ba

011272
S Cassiop.

Mo.	Day	Est.	Obs.
11	26	12.4	Nt

011208
S Piscium

Mo.	Day	Est.	Obs.
11	25	10.0	O
	26	10.3	Ba
	28	10.0	O
12	1	9.4	Y
	5	9.8	O

011712
U Piscium

Mo.	Day	Est.	Obs.
11	26	12.4	Ba

012350
RZ Persei

Mo.	Day	Est.	Obs.
11	10	12.8	Y

012502
R Piscium

Mo.	Day	Est.	Obs.
11	2	9.0	Sp
	7	9.0	Pi
	10	8.8	R
	25	9.0	O
	26	8.8	Ba
	27	9.1	Pi
	28	9.0	Sp
12	5	9.1	O

013238
RU Androm.

Mo.	Day	Est.	Obs.
11	3	10.2	O
	6	10.0	Pi
	9	10.6	M
	10	10.7	R
	10	10.5	Y
	28	10.4	O

013338
Y Androm.

Mo.	Day	Est.	Obs.
11	3	10.0	O
	9	10.4	M
	10	10.3	Hu
	10	9.9	R
	27	10.8	Ba
	28	10.6	O

014958
X Cassiop.

Mo.	Day	Est.	Obs.
11	1	10.9	Pi
	10	12.0	Y
	26	11.3	Pi
	27	12.0	Ba
	28	12.0	Sp

015254
U Persei

Mo.	Day	Est.	Obs.
11	4	8.5	Bu
	6	8.4	Ly
	11	8.4	R
	12	8.3	Ly
	20	8.4	Ly
	27	8.2	Ba
	28	8.6	Pi
	28	8.5	Sp
	30	8.6	O
12	7	8.5	O

021024
R Arietis

Mo.	Day	Est.	Obs.
11	4	10.2	Bu
	6	10.2	Pi
	6	10.4	Ly
	10	10.4	Pi
	27	12.2	Ba

021403
o Ceti

Mo.	Day	Est.	Obs.
10	29	7.5	Ho
	29	7.4	E
11	2	7.3	Nt
	5	6.8	Ma
	6	6.9	Ly
	6	6.9	Pi
	6	7.3	Nt
	6	6.6	Bu
	7	6.5	Ma
	7	6.5	Hu
	7	6.8	Ho
	9	7.2	Nt
	9	6.6	Ma
	10	6.6	E
	10	6.7	Pi
	11	6.8	R
	12	6.5	Ly
	13	6.7	Nt
	16	6.2	Nt
	23	4.3	Nt
	24	4.6	Mu
	25	4.2	Nt
	25	4.4	Ma
	25	4.5	Mu
	25	4.7	Bu
	26	4.3	Hu
	26	4.1	Mu
	27	4.0	Pi
	27	3.7	Ba
	28	4.2	Nt
	28	4.0	O
	30	3.9	Nt
	30	4.1	O
12	3	4.0	O
	3	3.7	Cr
	5	3.8	O
	7	3.6	O

021656
S Persei

Mo.	Day	Est.	Obs.
11	4	9.4	Bu
	8	9.5	Ly
	9	9.4	Pi
	11	8.7	R
	26	9.2	Pi
	27	8.5	Ba
	28	8.7	Sp

022000
R Ceti

Mo.	Day	Est.	Obs.
11	27	11.4	Ba
12	1	10.6	Y

022150
RR Persei

Mo.	Day	Est.	Obs.
11	10	10.6	Y
12	1	11.3	Y

022813
U Ceti

Mo.	Day	Est.	Obs.
10	29	7.7	Ho
11	2	7.9	Nt
	7	8.2	Ma
11	7	7.7	Ho
	11	8.8	R
	25	8.8	Bu
	26	8.4	Ba
	30	8.9	Pi

023133
R Triang.

Mo.	Day	Est.	Obs.
11	2	10.6	O
	10	10.9	Hu
	27	10.4	Ba
	28	10.0	Sp

024356
W Persei

Mo.	Day	Est.	Obs.
11	4	9.8	Bu
	6	9.6	Hu
	8	9.6	Ly
	9	10.3	Pi
	11	10.4	R
	26	10.3	Pi
	27	10.3	Ba

030514
U Arietis

Mo.	Day	Est.	Obs.
11	26	12.0	B

031401
X Ceti

Mo.	Day	Est.	Obs.
11	7	8.8	Hu
	27	9.0	Pi
	30	9.0	Pi
	30	8.8	O

032043
Y Persei

Mo.	Day	Est.	Obs.
11	1	9.4	Ma
	4	9.4	Bu
	6	8.9	Hu
	7	9.7	Ma
	8	9.4	Ly
	9	9.7	Pi
	11	10.0	R
	27	9.7	Ba
	30	9.8	O

032335
R Persei

Mo.	Day	Est.	Obs.
11	4	9.4	Bu
	9	9.1	Pi
	11	9.1	R
	27	9.8	Ba

033362
U Camelop.

Mo.	Day	Est.	Obs.
11	1	9.0	Ma
	7	8.9	Ma
	11	8.9	R
	30	8.6	Pi

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1915—Continued.

035124
T Eridani

Mo.	Day	Est.	Obs.
11	3	11.7	Ho

035915
V Eridani

Mo.	Day	Est.	Obs.
10	29	8.3	Ho
11	1	8.2	Pi
	7	8.1	Ho
	26	8.3	Ba
	30	8.7	Pi

042215
W Tauri

Mo.	Day	Est.	Obs.
11	6	11.7	Ly
	10	12.6	Hu
	12	11.6	Ly
	20	11.4	Ly
	27	10.9	Ly
	27	12.1	Ba
	30	12.2	Nt

042209
R Tauri

Mo.	Day	Est.	Obs.
11	14	12.9	Sp

042309
S Tauri

Mo.	Day	Est.	Obs.
11	13	13.4	Sp

043065
T Camelop.

Mo.	Day	Est.	Obs.
11	10	13.5	Y

043208
RX Tauri

Mo.	Day	Est.	Obs.
11	9	10.2	Pi
	10	9.3	Hu
	26	8.6	Ba
	27	9.0	Pi
12	1	9.1	Y
	3	9.0	O

043274
X Camelop.

Mo.	Day	Est.	Obs.
11	2	8.2	Bu
	2	8.2	O
	2	8.1	Sp
	6	8.3	Pi
	7	8.0	O
	8	8.1	Ly
	9	8.4	Pi
	11	7.9	R
	12	8.2	Ly
	25	8.9	O
	25	8.8	Pi
	28	9.0	O
	30	8.8	Nt
	30	9.1	Pi
12	3	9.3	O
	5	9.0	O
	7	9.9	O

044617
V Tauri

Mo.	Day	Est.	Obs.
11	28	10.5	O
	30	10.2	Nt
12	1	10.2	Y

045514
R Leporis

Mo.	Day	Est.	Obs.
10	29	6.5	Hu
11	1	7.5	Pi
	2	8.0	M
	7	7.0	Ho
	14	7.3	Ho
	26	6.9	Ba

050022
T Leporis

Mo.	Day	Est.	Obs.
10	29	9.9	Ho
11	1	10.2	Pi
	7	9.6	Ho

050953
R Aurigae

Mo.	Day	Est.	Obs.
11	2	12.5	Sp

052034
S Aurigae

Mo.	Day	Est.	Obs.
11	6	9.3	Pi
	10	9.4	Pi
	30	9.3	Pi

052036
W Aurigae

Mo.	Day	Est.	Obs.
11	28	13.0	B
	30	11.1	Pi

052405
S Orionis

Mo.	Day	Est.	Obs.
11	2	8.1	M
	2	8.2	Bu
	3	8.2	Ho
	12	8.3	M
	14	8.0	Ho
	27	8.1	Ba
	29	8.6	M

053068
S Camelop.

Mo.	Day	Est.	Obs.
11	10	8.6	Y

053005
T Orionis

Mo.	Day	Est.	Obs.
11	2	10.0	M
	2	9.8	Bu
	3	9.7	Ho
	9	9.7	Pi
	12	9.5	M
	13	9.1	Ho
	13	9.7	Pi
	14	9.8	Sp
	27	10.4	Ba

053531
U Aurigae

Mo.	Day	Est.	Obs.
11	27	12.8	Ba
	28	12.9	B
	30	11.4	Pi
12	1	13.0±	Y

054319
SU Tauri

Mo.	Day	Est.	Obs.
12	1	9.4	Y

054920
U Orionis

Mo.	Day	Est.	Obs.
11	2	9.8	M
	9	10.4	Pi
	27	10.5	Ba
	29	10.0	M

054974
V Camelop.

Mo.	Day	Est.	Obs.
11	26	11.4	B
	26	11.5	Ba
	27	11.3	Ba
	28	11.0	O
	29	11.4	M
	30	11.1	Pi
12	3	10.5	O
	5	9.7	O

055353
Z Aurigae

Mo.	Day	Est.	Obs.
11	7	10.6	Pi

060224
S Leporis

Mo.	Day	Est.	Obs.
11	3	6.2	Ho

060450
X Aurigae

Mo.	Day	Est.	Obs.
11	7	10.2	Pi
	26	8.9	Ba
	28	8.8	B
	30	8.8	Pi

061702
V Monoc.

Mo.	Day	Est.	Obs.
10	29	10.8	Ho
11	7	10.7	Ho
	13	10.7	Pi
	27	8.9	Ba

063159
U Lyncis

Mo.	Day	Est.	Obs.
11	10	13.1	Y
	27	13.5	Ba

063558
S Lyncis

Mo.	Day	Est.	Obs.
11	1	12.0	Pi
	2	11.7	Sp
	10	11.2	Y
	13	11.4	Sp
	27	10.1	Ba
	28	10.2	O
12	5	9.9	O

065208
X Monoc.

Mo.	Day	Est.	Obs.
10	29	7.8	Ho
11	7	7.6	Ho
	13	7.4	Pi

065820
TW Gemin.

Mo.	Day	Est.	Obs.
11	1	8.1	Pi
	2	8.3	M
	30	8.3	Nt
	30	8.4	Pi

070122 a
R Gemin.

Mo.	Day	Est.	Obs.
11	1	7.0	Pi
	2	7.4	M
	30	8.3	Nt
	30	7.7	Pi

070122
Z Gemin.

Mo.	Day	Est.	Obs.
11	2	12.3	M
	30	12.5	Nt

070310
R Can. Min.

Mo.	Day	Est.	Obs.
11	13	9.5	Pi

072708
S Can. Min.

Mo.	Day	Est.	Obs.
10	31	9.4	M
11	8	8.8	Ly
	12	8.8	M
	13	8.7	Pi
	20	8.6	Ly
	27	7.9	Ba
	29	8.2	M

072811
T Can. Min.

Mo.	Day	Est.	Obs.
11	14	10.0	Sp

073508
U Can. Min.

Mo.	Day	Est.	Obs.
11	27	9.5	Ba

073722
S Gemin.

Mo.	Day	Est.	Obs.
11	2	10.8	M

074322
T Gemin.

Mo.	Day	Est.	Obs.
11	1	8.7	Pi
	2	8.8	M
	30	9.2	Pi

075813
U Puppis

Mo.	Day	Est.	Obs.
11	3	12.2	Ho

081112
R Cancri

Mo.	Day	Est.	Obs.
11	1	10.9	E

082405
RT Hydre

Mo.	Day	Est.	Obs.
11	3	8.4	Ho

083019
U Cancri

Mo.	Day	Est.	Obs.
11	14	10.1	Sp

084838
S Hydrae

Mo.	Day	Est.	Obs.
11	1	10.0	E
	14	8.8	Sp

085008
T Hydrae

Mo.	Day	Est.	Obs.
11	1	9.0	E

090151
V Urs. Maj.

Mo.	Day	Est.	Obs.
11	1	10.5	Pi
	13	11.0	Pi
	27	11.0	Ba

090425
W Cancri

Mo.	Day	Est.	Obs.
11	14	12.8	Sp

093014
X Hydrae

Mo.	Day	Est.	Obs.
11	1	12.7	E

093178
Y Draconis

Mo.	Day	Est.	Obs.
11	10	13.2	Y

094211
R Leonis

Mo.	Day	Est.	Obs.
11	1	5.5	E
	2	5.8	M
	12	5.6	M

094622
Y Hydrae

Mo.	Day	Est.	Obs.
11	3	6.4	Ho

095421
V Leonis

Mo.	Day	Est.	Obs.
11	14	9.3	Sp

103769
R Urs. Maj.

Mo.	Day	Est.	Obs.
11	8	10.5	Ly
	11	9.0	Ba
	12	8.9	M
	12	10.1	Ly
	13	8.8	Pi
	20	9.0	Ly
	20	8.0	Ba
	26	7.7	Ba
	29	8.0	M

104620
V Hydrae

Mo.	Day	Est.	Obs.
11	3	6.9	Ho

123160
T Urs. Maj.

Mo.	Day	Est.	Obs.
10	29	8.5	E
11	1	8.5	E
	6	8.6	Nt
	6	8.5	Ly
	11	8.5	Ba
	12	8.7	Ly

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1915—Continued.

T Urs. Maj.

Mo.	Day	Est.	Obs.
11	20	8.9	Ly
	20	9.3	Ba
	27	9.3	Ly
	28	9.5	Ba
	29	9.7	M

123459
RS Urs. Maj.

11	28	10.8	Ba

123961
S Urs. Maj.

10	29	10.4	E
11	1	10.2	E
	6	9.7	Nt
	11	9.5	Ba
	15	9.0	M
	20	8.9	Ba
	28	8.6	Ba
	29	8.8	M

133273
T Urs. Min.

11	11	10.6	Ba

134440
R Can. Ven.

11	1	9.5	E

141567
U Urs. Min.

11	8	8.8	Ly
	11	8.8	Ba
	12	8.7	M
	20	8.6	Ly
	20	8.2	Ba
	27	8.0	Ba

141954
S Bootis

11	6	9.5	Nt

142584
R Camelop.

11	1	9.9	R
	2	10.3	O
	7	10.3	O
	8	10.2	Ly
	12	11.0	R
	20	10.6	Ly
	28	10.8	Ba

153378
S Urs. Min.

11	8	11.4	Ly
	11	11.3	Ba
	12	11.2	M
	12	11.5	Ly
	20	11.5	Ly
	20	11.8	Ba
	25	11.6	Pi
	28	12.2	Ba

154428
R Cor. Bor.

Mo.	Day	Est.	Obs.
10	25.5	6.4	Mu
	26.5	6.6	Mu
	29.5	6.5	Mu
11	2.5	6.3	Nt
	6.5	6.2	Nt
	7.5	6.3	Nt
	7.6	6.7	Mu
	9	6.0	Ph
	10.5	6.6	Mu
	13	6.5	Ph
	13.5	6.5	Nt
	17.5	6.5	Nt
	21.4	6.0	Ba
	30.5	6.3	Nt

155847
X Herculis

11	6	6.6	Nt
	9	6.5	Nt
	17	6.4	Nt
	30	6.5	Nt

160118
R Herculis

11	4	13.0	Hr

161138
W Cor. Bor.

11	21	8.7	Ba

162807
SS Herculis

11	6	10.0	Nt

163172
R Urs. Min.

11	1	9.5	E
	1	9.5	R
	4	9.0	Hr
	11	9.3	Ba
	12	9.5	R
	12	9.9	M
	12	8.9	Ly
	15	9.5	Hr
	20	9.5	Ba
	25	10.2	Pi
	28	9.5	Ba

163266
R Draconis

10	30	10.8	E
11	8	10.9	Ly
	11	10.9	M
	11	11.2	Ba
	20	11.5	Ba
	28	11.6	Ba
12	3	11.8	Cr

164055
S Draconis

11	1	9.3	R
	11	8.6	M
	12	9.0	R

171723
RS Herculis

Mo.	Day	Est.	Obs.
11	1	8.3	R
	12	9.1	R
	21	9.0	Ba
	28	9.6	Bu

172809
RU Ophiuchi

11	1	8.5	M

175458
T Draconis

11	11	9.8	M
	11	9.8	Ba
	26	10.1	Y
	28	10.3	Pi
	28	10.6	Ba

175519
RY Herculis

10	30	13.0	E
11	26	11.2	Y

180565
W Draconis

11	10	11.8	Y
	11	11.8	M
	26	10.1	Y
	28	9.8	Pi
	28	10.4	Ba

180531
T Herculis

11	5	11.9	Hu
	6	9.9	Bu

180666
X Draconis

11	11	10.8	M

181136
W Lyrae

11	5	12.6	Hu
	6	12.1	B
	25	12.4	B

182224
SV Herculis

11	3	9.6	B

183308
X Ophiuchi

11	1	7.2	R
	1	7.3	M
	4	7.8	Hr
	6	7.5	Ma
	11	6.9	Ba
	12	7.7	R
	15	7.4	Hr
	17	7.8	Ma
	20	7.1	Ba
	25	8.0	Ma
	28	7.4	Ba
	28	8.2	Bu

184205
R Scuti

Mo.	Day	Est.	Obs.
10	24.6	6.0	Mu
	25.5	5.9	Mu
	26.5	6.0	Mu
	29.5	6.1	Mu
	30.5	5.8	Ma
11	1.6	5.2	R
	1.6	5.8	Mu
	2.5	5.7	Nt
	3.6	5.7	Mu
	4.6	5.3	R
	5.5	5.5	Ma
	5.6	5.8	Mu
	6.5	5.7	Ma
	6.6	5.9	Mu
	6.6	5.8	Nt
	7.4	6.0	Hu
	7.4	5.2	Pi
	7.5	5.6	Ma
	7.6	5.6	Mu
	9	5.2	Ph
	9.5	5.7	Nt
	10.5	5.2	Mu
	10.6	4.3	R
	11.5	5.6	Ba
	11.6	4.1	R
	12.6	4.7	R
	13	5.0	Ph
	13.5	5.6	Nt
	18.5	5.7	Nt
	20.4	5.2	Ba
	25.5	4.8	Mu
	25.5	5.1	Ma
	28	5.8	Ph
	28.4	5.3	Ba
	28.4	5.0	Bu
	30.5	5.4	Nt

184243
RW Lyrae

11	2	11.5	B
	11	11.8	Ba
	20	11.6	Ba
	25	11.4	B
	26	11.7	Ba

185243
R Lyrae

11	1.7	4.1	R
	12.6	3.9	R

190108
R Aquilae

11	1	7.7	M
	4	7.1	R
	9	7.6	M
	11	7.5	Bu
	12	8.2	R
	20	7.5	Ba

190967
U Draconis

11	7	12.0	Hu

190926
X Lyrae

Mo.	Day	Est.	Obs.
11	1	9.3	M
	1	8.6	R
	6	9.1	Ma
	8	8.9	Ly
	11	9.4	Bu
	20	9.0	Ba

191033
RY Sagittarii

11	1	6.7	R
	4	6.2	R
	10	6.7	R
	11	6.7	R
	12	6.7	R

191637
U Lyrae

11	28	12.5	Ba

193449
R Cygni

11	5	10.8	Hu
	11	11.4	Ba
	20	11.8	Ba
	26	10.8	Hu
	27	11.8	Ba

193509
RV Aquilae

11	9	11.7	M
	15	12.0	Hr
	28	12.5	Ba

193732
TT Cygni

11	1	7.5	Ma
	1	8.2	R
	5	7.9	Hu
	5	7.8	Ma
	9	7.8	Ma
	10	8.0	Pi
	12	8.1	R
	12	8.3	M
	20	7.4	Ba
	25	8.5	Ma
	28	7.4	Ba

194048
RT Cygni

11	1	7.6	Ma
	1	8.6	R
	3	7.5	O
	5	7.3	Hu
	5	7.8	Ma
	6	7.7	Bu
	7	7.8	O
	8	7.8	Ly
	9	8.0	M
	9	7.8	Ma
	11	7.8	Ba
	12	8.0	R
	20	8.1	Ly
	20	8.0	Ba
	25	8.5	O

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1915—Continued.

RT Cygni

Mo.	Day	Est.	Obs.
11	25	8.3	Ma
	27	8.1	Ba
	30	8.8	O
12	3	9.1	O
	5	9.2	O

194348
TU Cygni

Mo.	Day	Est.	Obs.
11	4	9.2	R
	6	9.0	Ly
	6	9.4	Bu
	9	9.5	M
	11	9.2	Ba
	12	9.2	R
	20	9.0	Ly
	20	8.8	Ba
	27	9.0	Ba
12	3	10.2	O

194632
χ Cygni

Mo.	Day	Est.	Obs.
11	2	10.5	E
	3	10.4	O
	4	10.0	R
	5	9.9	Hu
	5	9.9	M
	6	10.4	Bu
	7	10.3	O
	11	9.5	Ba
	12	10.3	R
	12	9.8	M
	20	8.9	Ba
	25	10.2	O
	26	9.8	Y
	27	8.8	Ba
	28	10.0	O
	28	10.3	Bu
12	3	9.8	O
	5	9.8	O

195116
S Sagittae

Mo.	Day	Est.	Obs.
10	24.6	5.8	Mu
	25.5	5.7	Mu
	26.5	5.7	Mu
	29.5	5.6	Mu
	31.6	5.5	R
11	1.6	5.5	R
	1.6	5.6	Ma
	1.6	5.4	Mu
	2.4	5.7	O
	3.4	5.6	O
	3.6	5.8	Mu
	4.6	5.8	R
	5.5	6.0	Mu
	5.6	5.7	Mu
	6.5	5.7	Ma
	6.6	5.6	Mu
	7.4	5.4	O
	7.5	5.8	Ma
	7.6	5.5	Mu

S Sagittae

Mo.	Day	Est.	Obs.
11	9.5	6.0	Ma
	10.5	5.7	R
	11.6	5.7	R
	12.6	5.8	R
	17.5	5.4	R
	24.6	5.5	Mu
	25.5	5.4	Ma
	25.5	5.4	Mu
12	5.4	5.4	O
	7.4	5.7	O

195849
Z Cygni

Mo.	Day	Est.	Obs.
11	6	12.5	B
	25	9.6	
	28	9.4	Sp
	28	9.6	Ba
12	3	9.4	Y

200357
S Cygni

Mo.	Day	Est.	Obs.
11	25	9.4	

200647
SV Cygni

Mo.	Day	Est.	Obs.
11	1	9.3	Ma
	4	9.5	R
	5	9.3	Ma
	5	8.6	Hu
	6	9.1	Ly
	9	9.1	Ma
	12	9.0	Ly
	12	9.3	M
	20	9.0	Ly
	20	8.3	Ba
	25	9.2	Ma
	25	9.4	Pi
	27	8.9	Ly
	28	8.6	B
	28	8.6	Ba

200715a
S Aquilae

Mo.	Day	Est.	Obs.
11	4	10.1	R
	9	10.1	M
	11	9.4	Bu
	20	9.7	Ba

200715 b
RW Aquilae

Mo.	Day	Est.	Obs.
11	1	9.0	R
	4	9.2	R
	9	9.4	M
	10	9.2	R
	11	9.3	R
	11	9.0	Bu
	12	9.2	R
	20	9.4	Ba

200812
RU Aquilae

Mo.	Day	Est.	Obs.
11	2	9.6	B
	11	9.0	Bu
	26	10.4	Y

200916
R Sagittae

Mo.	Day	Est.	Obs.
11	4	8.6	R
	9	7.8	M
	20	9.0	Ba

200906
Z Aquilae

Mo.	Day	Est.	Obs.
11	26	10.1	B

200938
RS Cygni

Mo.	Day	Est.	Obs.
11	1	7.4	Ma
	4	7.4	R
	5	7.5	Ma
	5	8.6	M
	6	7.3	Pi
	6	7.4	Bu
	9	7.5	Ma
	12	7.3	Ly
	20	7.2	Ly
	20	7.3	Ba
	25	7.6	Ma
	25	7.5	Pi
	27	7.3	Ly

201008
R Delphini

Mo.	Day	Est.	Obs.
11	2	13.0	B

201121
RT Capricorni

Mo.	Day	Est.	Obs.
11	4	7.8	R
	21	6.6	Ba

201647
U Cygni

Mo.	Day	Est.	Obs.
11	4	8.5	R
	6	8.0	Mu
	6	7.9	Pi
	10	8.2	Mu
	11	8.8	Bu
	12	8.2	M
	12	8.3	Ly
	20	7.5	Ba
	25	7.6	Pi
	27	8.5	Ly
	30	7.9	S
12	5	7.3	O

202539
RW Cygni

Mo.	Day	Est.	Obs.
10	30	9.4	Ma
11	4	8.7	R
	5	9.4	Ma
	5	9.2	M
	6	9.2	Pi

RW Cygni

Mo.	Day	Est.	Obs.
11	9	9.1	Ma
	9	9.5	M
	10	8.8	Ph
	12	9.1	Ph
	12	9.0	Ly
	20	8.7	Ba
	25	9.2	Ma
	25	9.1	Pi
	27	9.1	Ly

202946
SZ Cygni

Mo.	Day	Est.	Obs.
11	1	10.2	R
	4	10.3	R
	5	8.6	Hu
	5	9.2	M
	9	9.3	M
	10	10.0	R
	11	10.3	R
	12	10.6	R
	20	9.0	Ba
	21	8.8	Ba
	22	8.6	Ba
	26	9.3	Ba
	27	9.5	Pi
	27	9.4	Ba
	28	9.5	Ba

202954
ST Cygni

Mo.	Day	Est.	Obs.
11	6	10.1	B
	9	10.2	Hu
	11	9.5	Bu
	27	11.2	Pi
	28	11.3	B

203226
V Vulpeculae

Mo.	Day	Est.	Obs.
11	7	8.5	Pi
	7	8.7	O
	20	9.0	Ba
	26	8.9	O
	28	9.1	Ba

203611
Y Delphini

Mo.	Day	Est.	Obs.
11	2	12.6	B
	10	12.4	Y
	28	13.0	B
12	3	12.6	Y

203816
S Delphini

Mo.	Day	Est.	Obs.
11	10	10.5	Pi
	10	10.8	Y
	28	9.8	Pi
12	3	9.9	Y

203847
V Cygni

Mo.	Day	Est.	Obs.
11	5	9.6	M
	6	8.6	B
	11	8.8	Bu
	20	8.4	Ba
	25	8.3	B
	28	8.3	Ba

204016
T Delphini

Mo.	Day	Est.	Obs.
11	10	12.5	Y
	28	10.6	Pi
12	3	13.0±	Y

204318
V Delphini

Mo.	Day	Est.	Obs.
11	2	9.4	B
	3	10.5	O
	10	9.9	Y
	20	10.1	Ba
	28	10.7	O
	28	10.1	B
	28	10.1	Ba

204405
T Aquarii

Mo.	Day	Est.	Obs.
11	2	8.9	B
	4	9.4	R
	6	9.0	Hu
	6	9.1	B
	21	10.8	Ba
	28	11.0	Ba

204846
RZ Cygni

Mo.	Day	Est.	Obs.
11	10	11.1	Y
12	3	11.3	Y

205017
X Delphini

Mo.	Day	Est.	Obs.
11	2	12.3	B
	10	12.8	Y
	28	13.0	B
12	3	13.0	Y

205923
R Vulpeculae

Mo.	Day	Est.	Obs.
11	5	11.6	Hu
	12	9.2	M

210116
RS Capric.

Mo.	Day	Est.	Obs.
11	4	8.3	R
	21	8.0	Ba
	28	8.5	Pi

210382
X Cephei

Mo.	Day	Est.	Obs.
11	10	9.8	Y

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1915—Continued.

210868
T Cephei

Mo.	Day	Est.	Obs.
11	1	6.8	Pi
	4	7.2	R
	7	6.5	Ma
	7	6.7	Hu
	11	6.6	Bu
	16	6.5	Nt
	20	6.6	Ly
	20	6.4	Ba
	25	6.5	Ma
	27	6.3	Pi
	28	6.2	Nt
	30	6.2	O
12	2	6.5	S

211614
X Pegasi

11	28	13.7	Ba

213244
W Cygni

11	4	6.9	R

213678
S Cephei

11	1	11.0	Pi
	7	10.0	Hu
	20	9.8	Ba
	27	10.8	Pi

213753
RU Cygni

11	4	8.5	R
	5	8.1	M
	22	7.5	Ba

213843
SS Cygni

10	29.7	9.4	E
11	1.6	11.1	M
	2.7	11.0	E
	3.5	11.7	Ba

SS Cygni

Mo.	Day	Est.	Obs.
11	5.6	11.8	Hu
	6.4	11.5	Pi
	6.4	11.9	Hu
	6.5	11.8	Nt
	6.5	11.4	Ly
	6.6	11.8	B
	7.5	11.6	Hu
	7.5	11.7	Nt
	8.7	11.4	E
	9.5	11.7	Ba
	10.5	11.9	Hu
	10.5	11.9	Pi
	12.5	11.6	Ly
	20.5	11.7	Ly
	20.5	11.8	Ba
	21.5	11.8	Ba
	22.5	11.8	Ba
	25.6	11.9	B
	26.5	11.8	Ba
	26.5	11.9	Hu
	26.6	12.0	B
	26.6	12.0	Nt
	27.5	11.8	Ly
	27.5	11.9	Ba
	27.5	11.9	Pi
	28.5	11.9	Pi
	28.5	11.8	Sp
	28.5	11.6	B
	28.5	11.6	Ba
	30.6	11.9	Nt

213937
RV Cygni

11	1	8.7	Ma
	4	8.4	R
	5	8.5	Ma
	5	8.1	Hu
	5	8.7	M
	7	8.6	Ma

RV Cygni

Mo.	Day	Est.	Obs.
11	7	8.3	Pi
	9	8.6	Ma
	12	9.0	M
	20	7.5	Ba
	25	8.6	Ma

214024
RR Pegasi

11	7	12.7	Sp

215934
RT Pegasi

11	10	9.8	Y

220714
RS Pegasi

11	10	10.0	Y

222439
S Lacertae

11	20	10.5	Ba
	28	11.1	Ba

225120
S Aquarii

11	1	8.8	Ma
	5	8.9	Ma
	7	8.6	Hu
	17	8.3	Ma
	20	8.5	Ba
	28	8.3	Ba

225914
RW Pegasi

10	31	11.0	Mu
11	6	10.8	Mu
	10	10.6	Mu
	22	12.3	Ba
	26	10.9	Mu
	28	11.1	Ba

230110
R Pegasi

Mo.	Day	Est.	Obs.
11	1	9.4	Ma
	2	9.3	O
	6	9.2	Ma
	6	9.2	Pi
	7	9.0	O
	10	8.6	R
	10	8.7	Pi
	10	8.7	Ph
	13	8.5	Ph
	20	7.2	Ba
	25	7.7	O
	25	7.9	Ma
	25	7.8	Pi
	28	7.4	O
	28	7.3	Ba
	30	7.3	Pi
12	3	7.5	O
	5	7.4	O

230759
V Cassiop.

10	1	7.5	Pi
	2	7.8	O
	7	7.9	O
	7	8.0	Sp
	10	7.5	R
	10	8.2	Nt
	20	8.0	Ba
	28	9.0	O
	28	8.4	Ba

231425
W Pegasi

11	6	11.3	Hu
	6	11.7	Ly
	12	11.8	Ly
	28	12.3	Ba

233335
ST Androm.

Mo.	Day	Est.	Obs.
10	29	9.6	E
11	6	9.9	Ma
	6	9.3	Hu
	6	9.5	Pi
	11	10.5	Bu
	12	10.1	Ly
	20	9.5	Ba
	28	10.1	Ba

233815
R Aquarii

10	29	8.5	E
11	5	8.8	Ma
	7	8.2	Hu
	9	8.8	Pi
	10	8.6	R
	22	8.6	Ba
	25	9.1	Ma
	28	8.7	Ba

235209
V Ceti

11	28	10.5	Ba

235350
R Cassiop.

11	10	7.1	R
	10	7.3	Nt

235525
Z Pegasi

11	2	9.6	O
	7	9.8	O
	22	9.2	Ba
	25	9.7	O
12	3	9.5	O

235939
SV Androm.

11	6	11.6	Hu
	6	12.3	Sp
	26	12.6	Hu
	28	12.6	Sp

No. of observations 919; No. of stars observed 179; No. of observers 20.

The Association is greatly indebted to Professor Pickering, and the members of the Observatory staff for their cordial reception, the many privileges extended, and the courtesies shown us which made the occasion ever memorable.

The following members were present: Messrs. Bouton, Burbeck, Hunter, McAteer, Nolte, Olcott, Pickering, Spinney, Steuart, and Wilson.

Mr. Burbeck deserves great credit for his successful and efficient management of the affair. He entertained several members at his observatory in North Abington.

Mr. McAteer brought greetings from the Allegheny Observatory, and on his way back to Pittsburg visited the Dudley Observatory at Albany, N. Y.

Members will kindly observe the variable *021403 o* Ceti at every opportunity, as Mr. Campbell is observing this star with the photometer. This will enable him to check up the probable error of the individual observers.

The irregular variables 060547 SS Aurigae, 074922 U Geminorum, and 213833 SS Cygni, should be constantly observed by every member.

The following members contributed to this report:—Messrs. Bancroft, Bouton, Burbeck, Crane, Eaton, Harrell, Hunter, Lindsley, Mach, McAteer, Mundt, Nolte, Olcott, Phillips, Pickering, Richter, Spinney, Miss Swartz and Miss Young.

William Tyler Olcott,
Corresponding Sec'y.

Norwich, Conn.
Dec. 10, 1915.

Results of Variable Star Observations.—Below I give the results of some of my observations of variable stars which you can insert in P. A. if you can find space.

Variable	Designation	Phase	Date 1915	Mag.	Number of Observations	First Observation		Last Observation	
						Date 1915	Mag.	Date 1915	Mag.
S Urs. Maj.	123961	Max.	June 21	7.6	24	Mar. 28	10.1	Nov. 11	9.5
"	"	Min.	Oct. 3	11.6					
T Urs. Min.	133273	Max.	Sept. 16	9.2	11	July 6	12.5	Nov. 11	10.6
SS Herculis	162807	Max.	Aug. 12	9.15	10	June 17	12.8	Sept. 27	12.3
W Herculis	163137	Max.	July 7	8.4	11	Apr. 4	12.7	Oct. 3	12.2
R Draconis	163266	Max.	July 30	7.2	21	Apr. 6	12.0	Nov. 28	11.6
RV Herculis	165631	Max.	Aug. 7	11.2	6	June 29	13.8	Nov. 2	12.0
W Lyrae	181136	Max.	Aug. 9	8.15	10	June 17	9.9	Oct. 27	12.3
RV Aquilae	193509	Max.	Sept. 19	9.8	6	July 24	12.7	Nov. 28	12.5
T Aquarii	*204405*	Max.	Sept. 19	7.3	8	July 18	10.7	Nov. 28	11.0
S Lacertae	222439	Max.	Sept. 20	8.5	6	Aug. 13	10.2	Nov. 28	11.1

Total number of observations 113.

A curve was plotted for each star.

H. C. Bancroft, Jr.

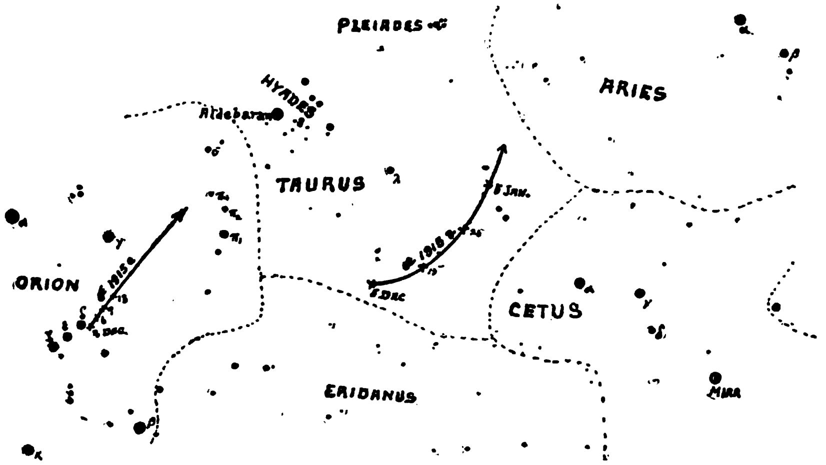
α Orionis.—Mr. F. E. Seagrave asks that we call attention to the great decrease in the light of Betelgeux (α Orionis). Early in December it was only slightly superior to Aldebaran (α Tauri), only .05 magnitude brighter. It was down to about where it was in February 1911.

Mira (*o* **Ceti**) was bright, about third magnitude, during the early days of December. The position of this wonderful variable star is shown on the same chart with the apparent paths of the two comets (see page 72).

COMET AND ASTEROID NOTES.

Comet 1915 *a* **(Mellish).**—The first comet of the year 1915, which went so far south during the summer months as not to be visible in our northern latitudes, is now north of the equator again and is moving slowly in the constellation Taurus. Its course for December is shown on the same diagram with that of the new comet 1915 *e* (Taylor). No ephemeris is at hand extending beyond January 5, but from the general curve of its path the reader can extend its course approximately through the month. This comet is still easily seen in a small telescope but will decrease rapidly in brightness during next month.

New Comet 1915 *e* (Taylor).—Harvard College Observatory Bulletin 592 announced the discovery of a new comet on December 2 by Taylor, at Cape of Good Hope. The announcement from Cape of Good Hope came by way of Greenwich and Copenhagen and was apparently delayed two or three days. On December 2 the comet was three minutes (of time) west and sixteen minutes (arc) south of δ Orionis. It has since been moving very slowly almost directly northwest, toward Aldebaran. At the present rate of motion (Dec. 16) it will be in the vicinity of Aldebaran toward the end of January. The comet is not a conspicuous object in the telescope but is easily seen with our 5-inch finder. The accompanying diagram shows the apparent course during December.



Comets 1915 *a* (Mellish), 1915 *e* (Taylor) and Mira (*o* Ceti).

The following observations have come to hand.

Greenwich Mean Time	R. A.	Dec.	Observer	Place
	h m s	° ′ ″		
Dec. 6.6957	5 22 42.9	+0 01 36	Burton	Washington
6.7597	22 40.31	0 02 10.5	Van Biesbroeck	Williams Bay
7.6577	22 11.58	0 12 06.4	Wilson	Northfield
7.7719	22 07.5	0 13 24	Van Biesbroeck	Williams Bay
7.8892	22 04.7	0 14 37	Aitken	Mt. Hamilton
8.7004	21 36.8	0 24 05	Burton	Washington
9.6817	21 03.30	0 36 02.5	Wilson	Northfield
13.7012	5 18 39.71	+1 30 23.9	Wilson	Northfield

The following elements and ephemeris were computed by Miss Levy and Mr. Shane of the Student's Observatory, Berkeley, California, from observations on December 7, 8 and 9. They were telegraphed to Harvard College Observatory and from there distributed in Bulletin 595, issued December 13.

Elements of Comet 1915 *e* (Taylor).

$T =$ 1915 November 4.84 Gr. M. T.
$\omega = 315^\circ\ 55'$
$\Omega = 107\ \ 44$
$i = 27\ \ 09$
$q = 2.543$

These elements are very uncertain because of the very slow movement of the comet.

EPHEMERIS.

		R. A.	Dec.	Light
		h m s	° ′	
1915 Dec.	12.5	5 19 25	+1 11	0.99
	16.5	5 17 07	2 03	
	20.4	5 14 53	2 59	
	24.5	5 12 47	+3 56	0.94

GENERAL NOTES.

Mr. G. Van Biesbroeck, who is spending this year at the Yerkes Observatory, intends to undertake the discussion of the observations of comet 1913 *f* (Delavan). He requests that unpublished observations of the comet be communicated to him as soon as possible.

Dr. R. W. Wood, professor of physics at Johns Hopkins University, has returned to Baltimore from the Mount Wilson Observatory, where he has been engaged in photographing the moon, Saturn and Jupiter by yellow light and ultra violet and infra red rays. (*Science* Dec. 3, 1915).

Professor S. A. Mitchell, director of the Leander McCormick Observatory, lectured at the Brooklyn Institute of Arts and Sciences on November 20, on "The Exact Distances of the Stars." On November 22 he lectured in Harrisburg before the Natural History Society on "The Sun."

Carl Axel Robert Lundin, who as a member of the firm of Alvan Clark & Sons had a large share in making several of the largest telescopic lenses in the world, died at his home in Cambridge on November 28.

Professor John A. Miller, director of the Sproul Observatory of Swarthmore College, has been chosen to give the Westbrook lectures before the Wagner Institute of Free Science in Philadelphia. This is a course of five lectures to be given in February and March. The general subject will "Aspects of Modern Astronomy."

New Edition of Boss' Catalogue.—From the *Bulletin Astronomique* we learn that the Carnegie Institution of Washington has decided to publish a new edition, by photographic reproduction, of the "Preliminary General Catalogue of 6188 Stars" the first edition of which has been exhausted for some time.

New Observatory for Duluth, Minnesota.—We learn from *The Duluth Herald* of December 3 that Mr. John H. Darling of Duluth, Minnesota, has promised to build an observatory on one of the public playgrounds of that city. It is to be built as a private observatory, but is to be open at stated times to those interested in astronomy. It is said to be Mr. Darling's plan to turn over the observatory either to the city or to some educational institution that will care for it after his death. It is planned to erect a brick structure, with a 20-foot dome and an adjoining library, the building to cost approximately $3000. The telescope is to be a 9-inch refractor, equatorially mounted and clock driven, to cost $3000.

Observed Rotations of Planetary Nebulae.—In *Publications of the Astronomical Society of the Pacific* No. 161, December 1915, Professor Campbell and Mr. J. H. Moore of the Lick Observatory announce that they have obtained spectrograms of the planetary nebula N. G. C. 7009 (R. A. $20^h\ 58^m$, Dec. —11° 48′), which yield positive proof of rotation of the nebula. When the slit of the spectrograph was placed parallel to the major axis of the nebula the lines were inclined with reference to the lines of the comparison spectrum; when the slit was parallel to the minor axis of the nebula no inclination of the lines was indicated.

"The ends of the lines corresponding to the west edge of the nebula are displaced to the violet with reference to the ends corresponding to the eastern edge of the nebula. The interpretation is that the rotation of the nebula is carrying the western edge toward us and the eastern edge away from us. The maximum rotational speed appears to be at approximately 9 seconds of arc from the center of the nebula and is in amount 6 kilometers per second. The extreme outer ends of the spectrum lines do not maintain their inclination at the full rate, but turn back slightly. This we interpret to mean that the law of rotation is such that the outer strata lag behind."

It is announced that positive evidence of rotational effects have been secured in the cases of two other nebulae, and suspected evidence in other cases.

A Meteor Star Atlas.—A very convenient star atlas for meteor observation has been published as *Publications of the Dominion Observatory, Ottawa*, Vol. II, No. 7. It consists of 20 maps of portions of the sky, drawn by Dr. Reynold K. Young. The maps are constructed on the gnomonic or central projection so that areas of great circles across them are represented by straight lines. This atlas will be found very useful for the purpose of plotting meteor trails.

Orbits of Spectroscopic Binaries.—Numbers 8 and 9 of Volume II of the publications just referred to contain orbits of the spectroscopic binaries 1149 Groombridge and 23 Cassiopeiæ, the former orbit calculated by W. E. Harper and the latter by Reynold K. Young.

ELEMENTS.

	1149 Groombridge	23 Cassiopeiæ
$T =$	J. D. 2,419,341.776 ± 0.663	2,420,577.41 ± 0.27
$K =$	67.19 km ± 1.19	16.32 km ± 0.50
$\omega =$	152°.9 ± 24°.2	269°.71 ± 4°.10
$e =$	0.081 ± 0.027	0.405 ± 0.026
$\gamma =$	— 13.74 km ± 1.39	—4.06 ± 0.34
Period =	9.944 days	33.75 days
$a \sin i =$	9,127,000 km	7,020,000 km

Radial Velocities of Six Nebulae.—In *Publications of the Astronomical Society of the Pacific* No. 161, December 1915, Mr. Francis G. Pease gives the results of the determination of the radial velocities of six nebulae with the 60-inch Cassegrain spectrograph of the Mount Wilson Observatory. For the Dumb-bell nebula the exposure was 32½ hours, extending over five nights; for Messier 33 the exposure was 34½ hours. In each of these cases the slit was set on the brightest knot in the nebula.

	Velocity
Dumb-bell Nebula	— 63 km
Messier 33	—278 "
N. G. C. 7023	+ 0.7 "
N. G. C. 6572 (planetary nebula)	— 12 "
N. G. C. 6826 " "	— 8 "
N. G. C. 6891 " "	+ 38 "

An Introduction to the Study of Variable Stars.—By CAROLINE E. FURNESS, Ph. D., Director of the Vassar College Observatory. Houghton Mifflin Company, 1915. 12 mo., pp. xv + 327 with 14 plates and 36 figures in the text. $1.75 net (weight 30 oz).

This important work is "One of a collection of notable volumes by Vassar alumnae, published in commemoration of the fiftieth anniversary of America's oldest college for women." The author had been a teacher of Astronomy at Vassar for several years in connection with Professor Mary W. Whitney, and since Miss Whitney's retirement, is Professor of Astronomy and Director of the Observatory. The observation of variable stars has been carried on at Vassar for the past fourteen years and the author's work in this department has prepared her for the preparation of this book.

The most superficial reading of the book impresses one with an idea of its completeness and thoroughness of treatment, and leads to the remark that the title "Introduction" is perhaps excess of modesty, for the quality and quantity of the book entitles it to rank with works bearing more ambitious titles.

The work treats of all the subjects which one would naturally connect with the study of variable stars, and in addition goes into considerable detail in descriptions of the principles of spectrum analysis and the relation between the spectra of variable stars and their class of variation. It also describes in detail the principles underlying the different photometric instruments, the principles of photo-electric action and of radial velocity. As a result the student of this book can gain not only the methods of variable star observations, but also the meaning of the phenomenon of variation as interpreted by the modern theories of Astrophysics.

This work will naturally be compared with that of Hagen, of which the first two parts have already appeared. While it necessarily covers the same ground as Hagen's work, with similar treatment to some extent, yet it differs from his in several particulars, mainly in the points already mentioned, the inclusion of fundamental principles, and the extension to photographic and photo-electric methods. The author states that her work is "An introduction rather than a handbook and as such devotes more space to explanatory material than to an intensive treatment of results of research."

The first chapter is introductory, and treats in a provisional way of stellar variation, the representation of the elements of variation, the classes of variables, the principles of spectrum analysis, the relation between the spectral classes and the different kinds of variation. The reading of this chapter will thus give a good preparation for the more detailed treatment of the different points, given in the following fourteen chapters.

These fourteen chapters fall naturally into four divisions.

1. The observers equipment (chapters 2 to 5), maps, charts, catalogs, meaning of the term magnitude. (This corresponds to Part 1 in Hagen's work).
2. Photometry of variables (chapters 6 to 8), visual, photographic, photo-electric.
3. Use of the observations (chapters 9 to 11), light-scale, light-curves, elements of variation and predictions from elements.
4. Deductions from the data in the preceding chapters (chapters 12 to 15), eclipsing binary variables, long period variables, statistics of stellar variation, hints to observers, tables.

The many variable star observers both amateur and professional, who read and report to POPULAR ASTRONOMY, will find this book indispensable in their work. Chapter XV, "Hints for Observers" gives valuable directions in regard to the "(1) Use of telescope; (2) Time; (3) Identification of variable; (4) Methods of recording; (5) Precautions; Stars suitable for observers with different apertures, mounted and unmounted." A regard for these directions, which show the author to be experienced both as an observer and teacher, will save much trouble and uncertainty.

Chapters IX, "Formation of Light-Scale," and X, "Mean Light Curve," will enable the observer to reduce and plat his own observations. This will not only give his results in a more useful form, but will also add greatly to his independence and accuracy as an observer. It is no doubt useful to have the observation turned over to a central bureau even in a raw state, so to speak, but it is greatly to be desired that the observer should progress as fast as possible towards the condition in which he can turn out a finished product, and thus have a standard of his own by which to judge of his observations. To the reviewer, this seems to be the most valuable result which may be hoped from the study of this work.

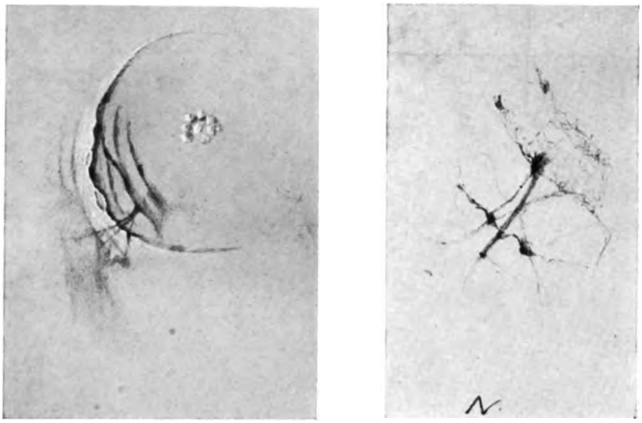
One of the most interesting recent discoveries from the observations of variable stars, is that the color deepens as the minimum is approached. This change is pretty well established for variables of the Cepheid type, and probably established for variables of long period. This change is most conveniently found from a comparison of visual and photographic light-curves. From the theoretical side this discovery is the most promising hint towards an explanation of the cause of variation of these types. The author seems to have omitted reference to this phenomenon, the only important omission, perhaps, in the book. Nevertheless, the variable-star work which the book will do so much to further, will furnish valuable data, especially from the visual side, for a comparison of visual and photographic curves, and therefore a test of the prevalence of this change in color.

With no desire to detract from the worth of the book, a few items may be mentioned, which from the standpoint of the reviewer might be modified to advantage. (1) The engravings of stellar spectra, Plates X, XI, XIII and XIV have no wave lengths on the margins, or anything to indicate the included range. This is rather puzzling to one who is not quite familiar with photographic spectra. (2) There is nothing to indicate the source of plates X and XI "Spectra of ζ Ursae Majoris and μ Orionis," which are evidently taken from the Bruce Spectrograms of the Yerkes Observatory. The spectrum of ζ Ursae Majoris is printed as usual with the red end of spectrum toward the right, while that of μ Orionis is reversed in direction. (3) Chapter V, "Stellar Magnitudes" lacks the important definition of "absolute magnitude", that is, the magnitude a star would appear to have if removed to a standard distance, 33 light-years, corresponding to a parallax of one-tenth of a second of arc. (4) On page 141 halation circles are mentioned as peculiar to refractor images and the statement is made that "this occurs only with a bright star, and cannot be avoided, ordinarily." It scarcely needs to be stated that this trouble is also present with reflector images, and can always be avoided by backing the plates.

The publishers, as usual, have done their work well. Good paper, large type, clear engravings and cuts, make a handsome volume which is worthy of high praise, both for its comprehensive plan and for the thoroughness and good judgment shown in carrying it out. It probably can be regarded as rather a supplement than a rival to Hagen's larger work, and is the only one of its class in any language, known to the reviewer. To foreign readers it may seem open to the criticism of being written too much from an American point of view, although it gives much space and credit to the work of the German pioneers and to the coöperation of the amateur observers in the British Astronomical Association. It should be found in every astronomical library and will doubtless be used in most of the schools where practical astronomy is taught. Vassar College is to be congratulated on the publication of such scholarly works in celebration of their fiftieth anniversary.

J. A. Parkhurst.

PLATE I



a FIG. 1. *b*

April 24, 7^h M.M.T. Colong. 37° by E. C. Slipher.

April 25, 8^h M.M.T. Colong. 49° by Dr. Lowell.

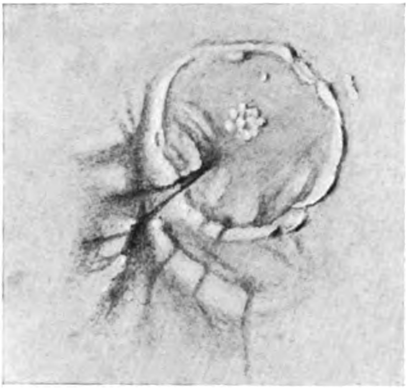


FIG. 2.
April 27, 11^{h}30^m M.M.T. Colong. 76°
E.C.S.

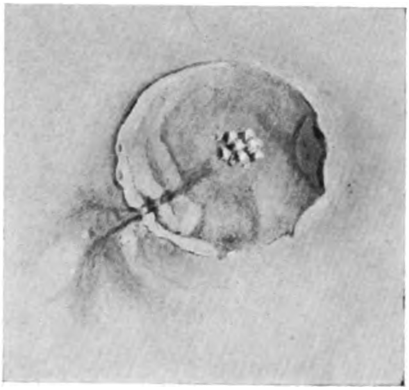


FIG. 3.
May 1, 16^{h}30^m M.M.T. Colong. 127°
E.C.S.

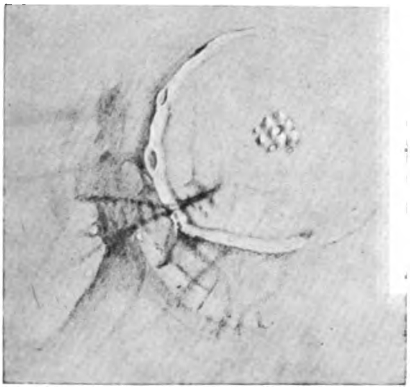


FIG. 4.
May 30, 14^{h}30^m M.M.T. Colong. 119°
E.C.S.

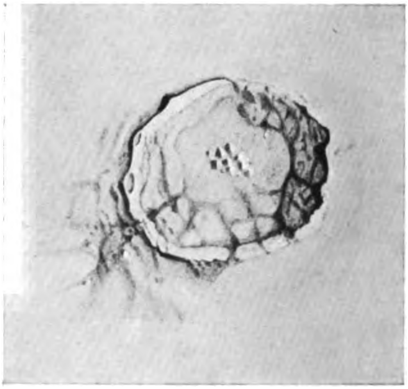


FIG 5.
May 2, 16^{h}00^m M.M.T. Colong. 139°
E.C.S.

THE LUNAR CRATER ARISTILLUS
DRAWN BY DR. PERCIVAL LOWELL AND MR. E. C. SLIPHER.

Popular Astronomy.

Vol. XXIV, No. 2. FEBRUARY, 1916. Whole No. 232

MARKINGS ON ARISTILLUS.

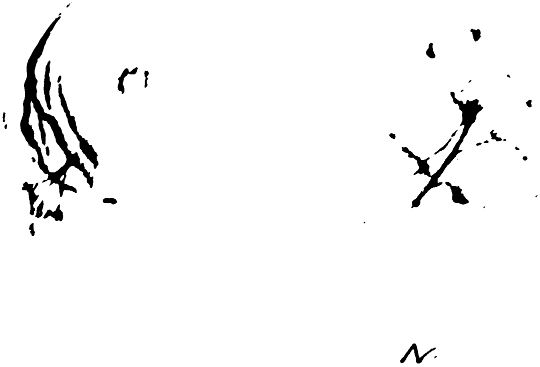
E. C. SLIPHER.

In the May and November (1914) numbers of POPULAR ASTRONOMY appeared articles, by Professor W. H. Pickering, concerning the unusual behaviour of certain markings in the lunar crater Aristillus. Similar changes, he says, occur in markings in Autolycus, Archimedes, Plato and others. He states as his belief that the changes in the appearance of the markings are produced by vegetable growth there.

At his request Dr. Lowell and the writer have studied these markings. Our particular attention was given to the markings on the northwest wall of the crater Aristillus, although the other craters were also examined, as they were said to present the most remarkable examples of the phenomena. They were critically observed here at various phases of the moon and during different lunations.

The first observations were made on April 23, 1915 and the last on June 28. For the former date the lunar co-longitude was about 25°. Sunrise on Aristillus occurred at colongitude 1°, thus the sunlight reached the walls of Aristillus but two days prior to the time of the first observations and the shadow of the wall upon the bed of the crater had just shortened sufficiently to uncover the markings. They were already obvious at a glance. They were found to consist of a pair of divergent, dark, narrow streaks which begin on the floor of the crater, cross step-like ridges to cut the northwest rim and then descend the outer slope, gradually becoming invisible in a few miles. Within the crater both are very slightly curved toward the south (See Fig. 1). The northern one keeps about the same general direction throughout its entire length; but the southern one is broken at the rim of the crater by a distinct offset and beyond this point it leaves the other marking at a rather sharp angle as it passes down the outer slope. Inside the crater the two diverge by only a few degrees, perhaps 8° or 10°, from the origin to the rim; on the outside the divergence is much greater, about 29°. There is a visible cleft in the wall where the markings

PLATE I



a Fig. 1. *b*

April 24, 7^h M.M.T. Colong. 37° April 25, 8^h M.M.T. Colong. 49°

by E. C. Slipher. by Dr. Lowell.

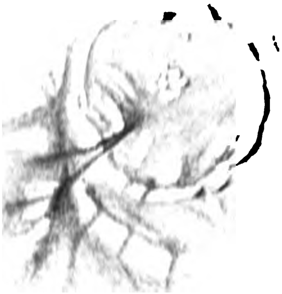


Fig. 2.

April 27, 11^{h}30^m M.M.T. Colong. 70°

E.C.S.

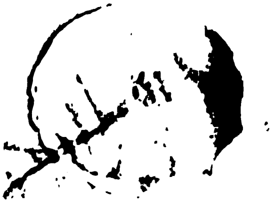
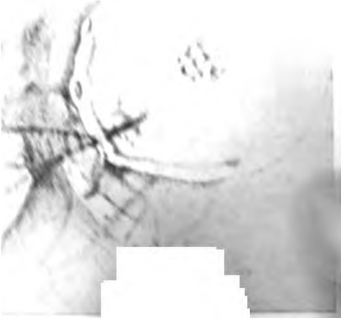
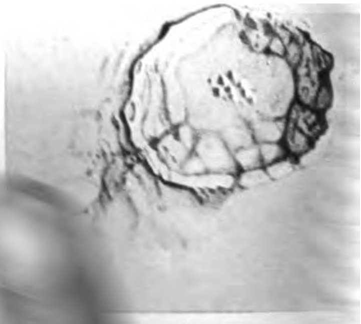


Fig. 3.

May 1, 16^{h}30^m M.M.T. Colong. 127

E.C.S.





May 30, 14^{h}30^m 119°

E

Fig 5.

^{h}00^m M.M.T. Colong

E.C.S.

Crate us

Lowell E. C. Slipher.

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ark the existence of
nces in the nature of
light received; and

emerge from the crater. In fact throughout their length they lie at a generally lower level than the adjoining country, and frequently appear to form the edge of elevated mesa-like regions; this is particularly true of the markings inside the crater. The inner ones were at all times darkest. Viewed as a whole the markings are not straight lines, or are they of uniform intensity; they show, rather, the broken, irregular appearance that would be expected of deep cracks partially lighted. Here and there they narrow and weaken in crossing the more brilliant places, but at the intersection of shaded spots there is a perfect blending and they widen out or grow more intense. Thus their contours are modified where they encounter shadows or partial shadows, and the two blend into one and the same thing. This often happens, and always the colors perfectly match. The shadows about the crater were of the same color and general appearance as the markings.

Many other markings of the same character as these are to be seen about the crater, mostly on the northwest wall and running in the same general direction. These, like the ones under discussion, appeared as rifts or cracks in the wall which were enhanced and brought into view by the shadows, or feeble illumination of their own walls. Not only this but other craters show markings of the precise character of these differing only in form; all apparently are shaded clefts. It is noteworthy that these markings always seem to occur on the northwest walls of the craters and to all have nearly the some position angle; that they occur on craters lying at a considerable distance from the moon's equator, all having a latitude of about 30° or more.

The sun's position with reference to Aristillus at the time of the observations.

Time of observation at Flagstaff	Altitude of ⊙ above Aristillus	Azimuth of ⊙	Direction of ⊙
h m	° ′	° ′	° ′
April 23 8 M.M.	+22 27	+104 19	East 14 19 S
" 24 7 "	31 40	112 15	" 22 15 "
" 25 8 "	41 0	122 58	" 32 58 "
" 27 11 30 "	55 14	156 24	S 23 36 E
May 1 16 30 "	41 53	235 45	W 34 15 S
" 2 16 "	33 16	246 8	W 23 52 S
" 3 16 30 "	23 29	255 0	W 15 0 S

No indication of vegetation resulted from the observations; on the contrary everything they disclosed tended to show that the markings are natural features in the lunar surface made to stand out by unequal illumination. They appear to be mere cracks, perhaps, of great depth, which run across the floor of the crater and through the wall to taper away till they become invisible on the slope outside. The inner markings indicate this more than the outer ones. Throughout they cross very rugged country but this only adds to the conviction that they are cracks, because it is usual for the lunar cracks to traverse plain and mountain alike, disregarding all inequalities. The fact that the markings do not exhibit any unusual color and that they so exactly match the shadows in tint favors the above belief.

If we leave out of consideration all of the known conditions adverse to life on the moon, and suppose it is just within the limit of possibility that a low form of vegetation might exist there, would it not still seem very strange to find a strip of vegetation beginning there on the floor of a crater and mounting the wall at an elevation of near 10,000 feet, an elevation almost equaling the altitude at which plant growth is limited on mountains in our temperate terrestrial climate. Add to this the extreme conditions of atmosphere and temperature that must exist on the moon, and the consequent adaptation required of vegetation at such varying altitudes, then the idea becomes incredible. Moreover the fact that the inner markings appear at practically the same moment the shadow leaves their locality, and that the markings outside disappear two or three days before sunset is strongly against the theory that they are vegetation. However, observations made at the precise time of full moon showed that these markings, which were so obvious only a few hours before, had wholly disappeared and their former place was marked in a general way by a faint bluish grey band that issued from the crater through the cleft wall to lose itself in the dusky patches outside. Not many hours after full moon this diffuse band, in turn, disappeared to give place again to the old markings. Thus the fact that they appear to grow more intense under a high sun only to fade out entirely at the hour of full moon, and to strikingly reappear not many hours later, not only precludes vegetation but at the same time obviously discloses their identity—shadowed cracks.

The dark areas or "fields" where the two markings in Aristillus are said to terminate are at no time very conspicuous. Their counterparts too, are to be seen elsewhere; in fact quite a great number are to be found scattered over the moon. They are dusky patches of a medium dark grey tone, of various sizes and forms, but otherwise they are all very similar. These dusky regions have always been seen by selenographers and are fairly marked when the moon is highly illuminated. If any photograph of the full moon be examined many of these dusky regions will be noted. It seems very likely that all these dark patches are caused by a like condition but since they cover such a large portion of the moon it can hardly be expected that they mark the existence of vegetation. They are produced, probably by differences in the nature of the surface which affect the power of reflecting the light received; and if they increase in intensity as the sun rises higher upon them, it must be only apparent and caused by contrast effects.

It was found, too that these markings on Aristillus do not resemble the double "canals" of Mars; not only do they differ in general appearance but also in the important respect that they are not parallel. The double "canals" of Mars are parallel throughout their length; these lunar markings diverge, first by about ten degrees and then, farther along, by as much as twenty-nine degrees. However there is another, an even more potent reason why they are not comparable to either the single or double "canals". It must be remembered that they measure but a few miles in length and in actual width only a few hundred feet, therefore if they were transferred to Mars all analogy would be lost at once, because they would become totally *invisible.* None of the moon's features bears any notable similarity to the canals of Mars.

USING THE AMERICAN EPHEMERIS.

FREDERIC CAMPBELL,* Sc. D.

Send one dollar to the Superintendent of Documents, Government Printing Office, Washington, D. C., and you will obtain a copy of "The American Ephemeris and Nautical Almanac," for the current year, or for either of the two following years that you name. The value for 1915 has 742 pages, made up of such masses of figures as may well appall the average amateur astronomer. The book is invaluable for professional astronomers and for navigators. But no effort has been made to make it popular, and to wish your dollar back will be very natural after a cursory examination.

While far more than 99% of the matter contained will be of no service whatever to the amateur, yet, in the remaining less than 1%, there is very valuable and interesting information, which can be dug out without much labor. If one take a diary or date book, and fill it in from this source, he will soon discover that he is constructing his own almanac, to which he can make constant reference as the days and months go by.

To the following items he will want to give attention:

1. The phases of the moon, day, hour and minute, Greenwich time, which he must translate into local time, an interesting process.

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* Former President Department of Astronomy, Brooklyn Institute.

2. The moon's perigee (nearest) and apogee (farthest), also in Greenwich time.

3. The moon's librations, east and west. These he will have to obtain from some other source, like Jayne's Almanac, to be had at the drug stores for the asking.

4. The moon's farthest north and south. These may be determined from the tables giving the moon's declination hour by hour, or from the moon's longitude and latitude table.

5. The moon's nodes, ascending and descending; this to be obtained from auxiliary almanac as above.

6. The moon's age; to be counted, day by day, from the day of new moon.

7. The discs of Mercury, Venus and Mars; found in the tables showing extent of illumination of the discs in percentages.

8. The light-time of Mars and Jupiter, from tables showing how long their light takes to travel to earth at different times.

9. Aspects of Jupiter's four principal satellites, graphically presented, their groupings, missing satellites, etc.

10. The stellar magnitude of various planets at different times, enabling one to compare their changing brilliancy with that of leading first-magnitude stars.

11. Occultations of planets and of principal stars that may be selected from the large number occulted, determined by the magnitudes given.

12. Eclipses. Not only are the facts given, but maps presented, showing the regions affected in case of solar eclipses. The total eclipse of the sun, visible in America in 1916, is soon to be reckoned with.

13. Times of rising and setting of sun and moon, to be obtained from auxiliary almanac. Day's length determined in connection therewith.

14. Various passing phenomena, known as "planetary configurations," conveniently covering two consecutive pages, and showing: a. conjunctions of planets with each other; b. conjunctions of planets and moon; c. planets' greatest brilliancy; d. conjunction of planets with sun; e. planets at quadrature; f. planets at opposition; g. planets' perihelion and aphelion; h. earth's perihelion and aphelion; i. planets' nodes; j. Mercury's and Venus' greatest elongations; k. planets stationary; l. solstices and equinoxes; m. Mercury's and Venus' greatest heliacal latitude north and south.

The process of making one's own almanac in this manner the writer finds to be of great interest; unconsciously one is familiarizing himself with many things about the heavens; and his self-made almanac, growing day by day, will mean more to him than any other.

Beaver Falls, N. Y.

THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

[*Continued from page 31.*]

GALILEO GALILEI.

Galileo* mentions the time of his first observations of the solar spots in four distinct places, as follows:

1st. In a letter to Giuliano de' Medici, the Ambassador of the Grand Duke of Tuscany at Prague.

2nd. In the first of his three letters to Welser.

3rd. In the *Dialogues on the Two Chief Systems of the World.*†

4th. In a letter to Cardinal Maffeo Barberini.

To Giuliano de' Medici he writes:‡

> The celestial discoveries are not yet at an end, it is about 23 months ¶ and more since I began to see some dark spots on the sun. And also in the past year ‖ in the month of April, being in Rome, I showed them to divers prelates and other gentlemen. Since then the report having been spread abroad they have been observed

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* Born February 15, 1564, died January 8, 1642. For a most interesting and inspiring account of the life of Galileo, the reader should consult, *Galileo, his Life and Work*, J. J. Fahie. New York, 1903.

† *Dialogo de Galileo Galilei Lincei ... sopra i due Massimi Sistemi del Mondo Tolemaico, e Copernicano.* Firenze 1632.

‡ *Galileo Galilei Opere, Edizione Nazionale,* **11**, 334. All references to Galileo's writings and correspondence are to the National Edition. For brevity this will be indicated by "*Gal. Op.*"

¶ In the *Edizione Nazionale* this figure is given as 15, with the footnote, "The figure is a little uncertain". The uncertainty of this figure has been the occasion of considerable discussion, caused largely because the figure was incorrectly given in several of the earlier editions of Galileo's works. Plana was the first to call attention to these errors in his *Réflexions* (*Op. Cit.* 168), where the handwriting of Galileo is reproduced in fac-simile, showing the manner in which the words "circa 23 mesi" are written. After examining this fac-simile, one appreciates that the 23 might have been mistaken for 13, but it is hardly conceivable that it could have been mistaken for 15. The figure 3 is unquestionable, but the 2 might be mistaken for 1. All the authorities, however, who have considered the matter agree in believing that 23 is the correct reading of this number. But Favaro in speaking of this letter remarks (*Op. Cit.* 737)."...... in the autograph at the library of the Imperial Observatory at Vienna we read clearly enough that this fact (the discovery) dates back '23 months and more' as Galileo writes." Just why in the face of this the figure should be given as 15 in the *Edizione Nazionale*, of which Favaro is the Editor, is not easy to answer.

‖ This fact makes the 2 in the figure 23 mentioned above, unquestionable.

> in many places, and various opinions have been written and spoken about this matter, but all far from the truth. I have finally convinced myself of this, which would at first sight perhaps seem very strange to you, namely, that these spots are not only near the sun, but contiguous to its surface, where continually some are being produced and others dissolved, some being of short and others of long duration; that is, some disappear in 2, 3, or 4 days, others remain for 15, 20, 30, and even more. They continually change shape, and these shapes are very irregular. They condense and they dissolve, some of them being at times very black, and others not so dark. Often one divides into 3 or 4, and at other times 2, 3, or more, coalesce into one. They have moreover a regular movement, by which they are all uniformly carried around by the solar globe itself, which revolves in a lunar month, with a motion similar to that of the celestial sphere, that is from the west to the east. These spots never occur near the poles of the sun's rotation, but only about the equator, nor are they found further from it than about 28 or 29 degrees, as far toward one pole as another; which region corresponds with the torrid zone of the earth, or to speak more correctly to that region which includes the greatest declinations of the planets.

The date of this letter, which is in autograph, is the 23rd of June 1612 which would make the discovery date back to July 1610.

In the first of the three letters to Mark Welser, already referred to, Galileo writes:*

> And in the first place there is no doubt whatever that these are real things, and not simple illusions of the eye or of the glasses, ... and I have been observing them for the last eighteen months, and I have shown them to several intimate friends of mine, and last year at just this time in Rome I showed them to many prelates and other gentlemen.

As the date of this letter is May 4, 1612, the statement that he had been observing the spots for eighteen months previously, would place the time of discovery early in November 1610. This apparent contradiction in dates has led to considerable discussion. In explaining it Plana† and Favaro‡ are agreed in believing that the first date refers to the time of actual discovery in July 1610; the second date, November, referring to the time when the observations were resumed after Galileo's removal from Padua to Tuscany in September 1610; he being able once more to resume the investigations and studies which had been interrupted by the inconveniences of moving. This argument is based on the words of Galileo himself. In the letter to Giuliano de' Medici, he writes:

> It is nearly 23 months and more since *I began to see* some dark spots on the sun. (Ma sono circa 23 mesi e piu che *comincial a vedere* nel sole alcune macchie oscure).

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* *Gal. Op.* 5, 95.

† *Op. Cit.* 168.

‡ *Op. Cit.* 738.

While to Welser, he writes:

> And I have been *observing* them for the last 18 months. (Ed io le *ho osservate* da 18 mesi in qua).*

The writer agrees with the explanation of this apparent contradiction as given by Plana and Favaro, namely, that the two dates refer to two different occasions; the first one to the approximate time of the discovery or first observation of the spots, the second referring to the observations which were resumed after Galileo's arrival in Tuscany. Why Galileo did not mention the earlier date in the letter to Welser, we have apparently no means of determining.

In the *Dialogues on the Two Chief Systems of the World*, published in Florence in 1632, alluding to himself, Galileo puts the following words in the mouth of Salviati:†

> He was the first discoverer and observer of the solar spots, as well as all other celestial novelties, [was] our member of the Accademia dei Lincei; and these he discovered in the year 1610, while he was still lecturer on mathematics at the University of Padua, and there and in Venice he spoke of them with various people, some of whom still live; and a year later in Rome he showed them to many gentlemen, as he asserts in the first of his letters to Mark Welser the Magistrate of Augsburg. He was the first, who, contrary to the opinions of those too timid and too jealous of the unalterability of the heavens, affirmed that these spots were material bodies, which were produced and dissolved in a short time, which were located contiguous to the body of the sun, around which they revolved, or were carried by the solar globe itself, which rotates in its place, without changing its position, in about a month,

In the letter to Maffeo Barberini, Galileo writes:‡

> About 18 months ago, looking with my telescope at the body of the sun when it was near to its setting, I perceived on it some rather darkish spots; and returning several times to the same observation I perceived that they were changing their positions, and that they were not always the same in form nor in arrangement; and sometimes there were many of them, sometimes few, and sometimes none at all. I showed this strange thing to my friends, and just last year in Rome I showed it to many prelates and men of letters.

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* Carrara (*Op. Cit.* 217) does not support the above explanation, not believing that much reliance should be placed on such indefinite statements, nor that the date in the letter to Giuliano de' Medici refers to the time of actual discovery, since neither the day nor the hour when the discovery was made are mentioned. Regarding the statement in the letter to Welser, Carrara believes that this refers to the times when the spots were shown to friends, that is, a simple view of the spots and not the beginning of a series of continued observations. The objection is also raised that Galileo should have made the more accurate statement in the reply to the letters of Apelles which was addressed to Welser, rather than in a letter to Giuliano de' Medici. Carrara also points out the great advantage that it would have been to Galileo in the unfortunate quarrel which followed, if in his earlier letters he had made more accurate statements regarding the time of discovery. However, reasoning of this kind, namely, what Galileo ought to have written is somewhat beside the question. The important point is to find the best interpretation of what Galileo did write, and not what he should have written.

† *Gal. Op.* **7**, 372.

‡ *Gal. Op.* **11**, 304.

This letter is dated June 2, 1612, and according to this, dating back eighteen months, the time of discovery was early in December 1610. This is at variance with the other statements, and since the only part of the letter which is in autograph is the signature, too great reliance should not be placed on it. From the similarity of the wording of many of the statements made in it with those in other letters, and the fact that only the signature is in autograph, one is led to believe that the letter may have been written for Galileo, at his request, by a friend or pupil. Accompanying the letter is a series of nine drawings of the sun, showing the spots day by day from May 3-11, 1612.

That Galileo had observed the spots while at Padua, and that he had shown them to his friends is incontestably affirmed by the declaration of Father Fulgenzio Micanzio, in a letter written after the publication of Scheiner's *Rosa Ursina**, in which that author claimed the priority of the discovery of the solar spots. The letter is dated September 27, 1631. Micanzio writes:†

> I remember most distinctly that when you had made here the first telescope, one of the things that you observed were the spots on the sun. And I could name the place and the point, where on a white card you showed them with your telescope to the Father of glorious memory [Paolo Sarpi]. And I remember the discussion that there was, first whether it was an illusion of the glass, or vapors intervening; and then after repeating the experiment, it was concluded that it was a fact and worthy of being philosophised upon; and then you went away. The memory of it is as fresh to me as if it were yesterday.

This letter is the strongest, and apparently the only direct testimony for the observations of the spots at Padua from one who was actually present at the time. It is to be noted that the statements of Galileo in the letter to Giuliano de' Medici and in the *Dialogues* are confirmed by the letter of Micanzio's and by Viviani in his *History*, which will be quoted later. It is true that this letter was written twenty years after the event had taken place, but the wording is so clear and the statement so convincing, the details so carefully given, that unless we have some real reason for doubting the veracity of the author, the letter almost compels confidence in the author's statement that, "The memory of it is as fresh to me as if it were yesterday." We know that Galileo left Padua early in September 1610 to accept the chair of Mathematics at the University of Pisa.‡ Hence, there are the very best of reasons for asserting that Galileo's first observations of the spots were made sometime before this date, that is, during the summer months of the year 1610.

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* *Rosa Ursina* is the title of Scheiner's great book on the solar spots, published in 1630.

† *Gal. Op.* **14**, 298.

‡ Fahie, *Galileo, his Life and Work*, p. 121.

The announcement of Galileo's discoveries of the mountains of the moon, and the satellites of Jupiter was made in the tract entitled *Siderius Nuncius*, published at Venice in March 1610; later in the same year were made the anagrammatical announcements of the triple bodied Saturn and the phases of Venus. The news of these discoveries spread over all Italy, creating intense excitement among the people, and consternation among the learned and the Church authorities. Galileo had already become known for his radical and revolutionary views upholding the Copernican theory of the solar system, and altho the statements in the *Siderius Nuncius* did not support this in so many words, the inference could easily be seen by his readers, and the result was a tremendous explosion of incredulity and malice. It is not necessary to go into the details of all this, but it was in consideration of the extraordinary interest, friendly and otherwise, excited by these epoch making discoveries, and the possibility of their being used against him by his enemies in Rome, who already were numerous, that Galileo thought it advisable to go there himself and to acquaint at first hand the dignitaries of the church and the savants with his work in the heavens. These people, he argued, must first be made to see the facts with their own eyes, so that they may be able to comprehend and assent to the conclusions to be drawn from them.

Galileo had removed from Padua to Pisa and was now under the authority of Cosimo II, Grand duke of Tuscany. Therefore on the 15th of January 1611, he wrote to Belisario Vinta, the secretary to the Grand Duke, informing him of his designs, adducing the above reasons and requesting the necessary leave of absence. The permission not only was granted, but the Grand Duke undertook to defray all expenses. Illness, however, intervened, so that it was not until toward the end of March that Galileo was able to set out. He was received with the greatest distinction by princes and all the church dignitaries, and was lodged at the Tuscan Embassy, with the Ambassador.

There are numerous letters and other documents which testify to the public exhibition of the spots and the other "celestial novelties." Piero Dini writes to Galileo from Rome on May 2, 1615:*

> I find myself here in the Monte Cavallo Gardens of the most illustrious Bandini, where you showed me for the first time the solar spots.

Angelo de Filiis, going into greater detail, writes:†

> [Galileo] does not depart from Rome before he not only indicates to you with words that the sun has spots, but shows it to you in fact; and he shows the spots from more than one place, as in particular the Quirinal Gardens of the most

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* *Gal. Op.* **12**, 175.

† *Gal. Op.* **5**, 81.

illustrious Cardinal Bandini, there being present at the time the Cardinal with the Most Reverend Monsignori Corsini, Dini, Abbate Cavalcanti, Signor Giulio Strozzi and other gentlemen.

Vincenzio Viviani, the first biographer and the last and best beloved pupil of Galileo, in his "Narrative History of the life of Galileo," (*Racconto Istorico della Vita de Galileo*) writes regarding this:*

> About the end of the month of March 1611, Galileo being desired and expected by all Rome, went there, and in the following April showed the new sights in the sky to many Cardinals and Prelates, and especially in the Quirinal Gårdens,......he showed the solar spots. And this was six months before the earliest observations made by a certain unknown Apelles, who then pretended the priority of this discovery in vain, for his first observations were not made before the month of October following.

Gio. Battista Agucchi writes to Galileo from Rome on June 16, 1612:†

> It is now more than a year since you spoke to me of the solar spots and concerning their movement about the body of the sun.

To adduce other evidence in support of the public exhibition of the spots at Rome would be superfluous. However, it is important to establish the time of Galileo's sojourn in that city. Fortunately the dates of his arrival and departure can be fixed with great exactness. Giovani Niccolini writes to Cosimo II, the Grand Duke, from Rome on March 30, 1611:‡

> Mess. Galileo Galileo arrived here yesterday, to whom, in conformity to the command in your letter of the 27th [of February], has been given lodging together with two of his servants.

Piero Guicciardini, who succeeded Niccolini in the office of Resident for the Grand Duke, writes from Rome on June 4, 1611, to Belisario Vinta:¶

> This morning Galileo departed from here, whom I have lodged in my house and tried to honor and care for as a person who is dependent upon and pleasing to the Most Serene Patron.

Hence, Galileo was in Rome from March 29, to June 4, 1611, and during this interval he showed the spots to the "many Cardinals and reverend gentlemen."

While Galileo was exhibiting the spots and other celestial objects in the Quirinal Gardens, a letter dated April 19, 1611,‖ was sent by Cardinal Roberto Bellarmine to the Most Reverend Father of the Collegio Romano inquiring concerning the truth of these new celestial discoveries made with the telescope. In consequence, four members of the Collegio Romano were appointed, and instructed to examine this matter and to report. The members of this commision were the Fathers Cristoforo Clavio, Cristoforo Grienberger, Odo von Maelcote, and Gio. Paolo Lembo; all being members of the order of Jesuits. The commissioners were of course constrained to admit what had been long denied and ridiculed. Their report was submitted with the date of April 24, 1611.* Altho the spots are not specifically mentioned in the report, they must have been shown to at least one of the members of this commission; for Maelcote writes to Kepler from Brussels, 11th of December 1612:†

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* *Gal. Op.* **19**, 612.

† *Gal. Op.* **11**, 329.

‡ *Gal. Op.* **11**, 78.

¶ *Gal. Op.* **11**, 121.

‖ *Gal. Op.* **11**, 87.

> Have those solar spots taught nothing new to your domination concerning the motion of the sun about its center? These spots, altho Galileo showed them to me in Rome and others in Germany, (fearing with you that the lens might burn the eye) I neglected to observe them, until having read of your device and somewhat modified it, I learned to observe by passing the rays of the sun through a dioptric tube provided with both its concave and convex glass and properly extended, on a tablet or card placed opposite to the sun. I wonder indeed that these spots do not recur in the same position and order if they move with an epicyclic motion, since they seem to hasten in front of the sun towards the west with the same velocity.

The reality and actual existence of the spots was thus admitted by the enemies of Galileo. Certain of them now attempted to rob him of the credit for the discovery. The foremost of these was Scheiner, who was of course aided in this by his co-religioners, the Jesuits. One of the strongest arguments of these enemies of Galileo in opposing his claims for the discovery, was that he did not announce it in an anagrammatical form or otherwise as he had thought well to do for the phases of Venus and the triple Saturn. "Meanwhile to speak of the spots is not to write of them; to see the spots is not to publish your writings," proclaims Scheiner.‡ Why Galileo did not endeavor to assure for himself, by his usual methods, the credit for the priority of discovery when he first saw the spots is not difficult to guess. One can suppose that in consequence of the discoveries of the satellites of Jupiter, the triple-bodied Saturn, the phases of Venus, and the mountains of the moon, with the unparalleled controversy that had been let loose by the conclusions that he had drawn from them, Galileo might well pause before announcing the discovery of such unstable objects as the sun-spots; which, changing their form and position, vanished and reappeared before his very eyes. However, Galileo himself tells us in his first letter to Welser his reasons for not announcing the discovery.¶

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* *Gal. Op.* **11**, 92.

† *Gal. Op.* **11**, 445.

‡ *Rosa Ursina*, lib. I. p. 25.

¶ *Gal. Op.* **5**, 94.

> I have kept silence in the hope of being able to give some satisfactory answer to your questions regarding the solar spots, concerning which you sent me the brief discourses by the unknown Apelles. But the difficulty of the matter, and my not having been able to make many continued observations, have kept me and still keep me undecided and irresolute, for it is more necessary for me than for many others to proceed with caution and circumspection in announcing any novelties. For the things recently observed, which are far from common and popular opinion, and which as you well know have been vigorously denied and opposed, place me in the necessity of being obliged to conceal and keep silent regarding any desirable new explanation, unless I have some demonstration of it which is more than convincing and plausible. Because by the enemies of novelties, the number of whom is infinite, every error no matter how slight would be considered a most grevious fault, for the custom has been established that it is better to agree in an error with everybody, than to be alone in reasoning correctly.

In this connection, Viviani in his *History of the Life of Galileo* writes as follows:*

> Continuing the celestial observations with the telescope, in the beginning of July he discovered Saturn to be tricorporate, ... He also saw in the face of the sun one of the spots, but at that time he did not announce this other novelty, which might so much the more draw upon him the envy and persecution of many obstinate Peripatetics (mentioning it only to some of his most intimate friends of Padua, Venice and elsewhere), in order that he might first assure himself with repeated observations, and thus be able to form a theory of their nature, and to pronounce his opinion of them with at least some probability.

The truth of this, namely, that Galileo was for some time in doubt regarding the true explanation of the spots and was still uncertain whether the spots were a part of the sun itself, or were of the nature of small planets revolving around it, is indicated by the first printed work by Galileo in which the spots are mentioned. This is the "*Discourse on Floating Bodies,*" (*Discorso intorno alle cose che stanno in su l' acqua o che in quella si muovono*). Galileo had finished writing this by the end of October 1611; it was licensed by the Holy Office on March 5, 1612, and appeared from the printer's hands during the latter part of May, In it, Galileo refers to the spots in the following words:†

> I add to these things the observations of some dark spots which are perceived in the body of the sun, which changing their positions in it offer an opportunity for argument whether the sun revolves in its place, or whether these spots are other celestial bodies like Venus and Mercury, and are revolving around it, invisible at other times on account of their small digressions from the sun, which are less than those of Venus and Mercury, and hence are only visible when they interpose between the sun and our eyes. The proof of these things ought not to be neglected or overlooked.

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* *Gal. Op.* **19**, 611.

† *Gal. Op.* **4**, 64.

Galileo had evidently more nearly convinced himself of the true nature of the spots by the time that he wrote the first letter to Welser. For in a letter to Prince Frederico Cesi, the founder of the Accademia dei Lincei, dated the 12th of May 1612, or about a week after the first letter to Welser, he writes:*

> About these spots, I finally conclude and believe that I can firmly prove it; they are near to the surface of the solar globe, where they are being continually created and dissolved, as are the clouds around the earth, and by the same sun they are carried around as it revolves in its place in a lunar month with a revolution similar to that of the other planets,......

And with greater assurance he writes to Cesi again, two weeks later.†

> I am very resolute and certain, that the fact will be found as I say; that is, that the spots are in the surface of the solar body itself, which carries them around, revolving in its place in the space of about a lunar month, from west to east in conformity with all other celestial motions. Here they are produced continually and they are dissolved, ... imitating in short the particular behaviour of our clouds, which being obedient to the greatest and universal movements of the earth, daily and annually do not fail to change their shapes and places among themselves, but within very narrow limits. Do not have any doubts regarding this, for I have the necessary demonstration of it.

In the second edition of the *Discorso* which appeared in August 1612, Galileo expresses himself more resolutely:‡

> Continued observations have finally convinced me that such spots are matter contiguous to the surface of the solar globe,......and by the rotation of the sun, which in about a month finishes its period, they are carried about its circumference; an event which is of greatest import in itself, and greater in its consequences.

It is thus seen that for a considerable time after the first observations; that is, until May 1612, Galileo was still uncertain regarding the true nature of the "dark spots which are perceived in the body of the sun," and hence hesitated to make the formal announcement. It is likely that the announcement would have followed in due time, when, after having convinced himself of what the spots were, he would be prepared to withstand the onslaughts of the Peripatetics. But before this the public demonstration at Rome had been practically forced on him. It is not unreasonable to suppose that Galileo believed that this demonstration was a sufficient announcement of the discovery and that no other was necessary.

The news of the sun-spots spread abroad in Italy, and, as we shall see later, in Germany. In Italy there were many who procured telescopes, and following Galileo's example, made numerous observations of the "celestial novelties." Among these, two are worth mentioning; the

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* *Gal. Op.* **11**, 296.

† *Gal. Op.* **11**, 301.

‡ *Gal. Op. A*, 64.

Cavalier Domenico Cresti di Passignano and Ludovico Cardi da Cigoli, two painters, both lifelong friends of Galileo. Passignano was the first to see the spots, but his friend Cigoli wrote to Galileo describing the observations. Cigoli writes from Rome on the 16th of September 1611, as follows:*

> I wanted to write to you with the last post that Passignano has obtained a telescope similar to the one that you have, from a friend in Venice. He says that with it he has observed the sun many times, in the morning, noon, and evening..... and that he has observed in the sun as many as eight spots, sometimes more, sometimes less, and in various aspects, sometimes darker and sometimes more faint (spenti), almost as if they had burned (infusi) themselves more or less into the center and middle of the luminous body,.......And he says he is sure that they move around within the said sphere of the sun; but I told him that he should observe them for a week, and sketch them and inform you about it. He said that he had done so, and that he positively insisted that they moved, and for that reason they go wandering through the solar body. However, I tell you this for your information.

Accompanying the letter is a rough sketch showing the positions of the spots. Cigoli writes other letters to Galileo concerning Passignano's observations. Finally Passignano writes to Galileo on December 30, 1611, as follows:†

> I believe that Sr. Ludivico [Cigoli] has written to you how with my telescope I have made some observations of clouds (nobi) on the sun, of which I am sending you a copy [this drawing is lost], where you will see the day and the hour that they were seen. I have shown them to Fathers Panberger and Malcotto [Grienberger and Maelcote], who say that they have seen them, and have asked me how it is possible to endure the sight of the sun? I have told them that in front of the small glass [eyepiece] I put a piece of blue glass which kills the heat of the sun. Now I would like you to see them, and if you will advise whether they agree with your observations and where they fail to agree, it will be pleasing to me.

Passignano was a careful observer, and, altho his theory of the spots would not stand present day tests, he is one of the first to give intelligent arguments for believing that the spots are a part of the sun itself. He writes to Galileo from Rome on the 17th of February 1612:‡

> Having seen a discourse which came from Germany about the spots which are seen on the sun [presumably the Apelles' letters], and having spoken about it with Father Panberger, who holds the same opinion as the writer of it, namely, that the spots which he sees are stars like those around Jupiter, I am of the contrary opinion, because I have made observations for five months, and I have not been able to perceive that they are outside of the sun. But I say that they are inside the body of the sun, because in the said time it is impossible that I should not have seen some of them in the neighborhood of the sun, as would happen if they were outside of it. But I have never seen them near the edge, instead they are first seen a little distance from it, not being plainly visible, and gradually as they

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* *Gal. Op.* **11**, 208.

† *Gal. Op.* **11**, 253.

‡ *Gal. Op.* **11**, 276.

> approach the middle they are seen more plainly. And similarly I have seen some in one day appear in the middle all at once, and then in several more days finish their course and vanish. And also I have seen some which when they have come to the middle vanish in a few days, and are no longer seen; and on account of these proofs I cannot believe that they are detached from the sun. If they are suddenly seen near the middle and finish their course in a few days, it must mean that they come suddenly, change their course a little and go away gradually; and on the other hand I have seen some come slowly and when they have become fainter, vanish near the middle. From which it would follow that their motion would be swift and slow and hence irregular, which is a thing I do not believe possible, for I believe that all the celestial bodies have a regular motion which does not change. I believe them to be inside the body of the sun, not only on the surface, but that they go down to the center and come back to the surface.

The letter continues, questioning Galileo whether he had observed the same things and requesting an opinion on the subject.

Cigoli writes a long letter to Galileo from Rome, dated March 23, 1612, in which he describes his methods of observing and the spots as they appear to him. His theory, however, shows very evident signs of the influence of Passignano. He mentions his telescope, which he declares to be a good one, because with it he can see the hands on the clock on St. Peter's from his position on Santa Maria Maggiore. About the spots, he writes:*

> The spots on the sun, I could not look at them with the little white glass, because tears came to my eyes, but then with a thick green glass and since it was concave like the white one, I placed on it another plane glass also green, I had no difficulty in observing them at any time. And from Santa Maria Maggiore I have made the 26 observations which are here enclosed, ... I would assert that in the sun there are things which are like bits of straw floating in a caraffe, which moving through it come to the circumference and are visible, then go down to the center, and as they go down become fainter. I do not know, but it seems to me most likely that they are stars which in passing interpose between us and the sun, altho I have some doubt of this (!). One reason is, that I have never seen them right at the circumference, but very close, and always entering from the east and going toward the west, but I have never seen any of them go to the very edge. I have seen many oval shaped (ovate), especially near the edge, but Father Grembergero [Grienberger] says that this is because we see a portion of the illuminated side, and hence they appear oval;† which reason would satisfy me, if it were not contrary to what my senses show me. But the oval ones that I have seen appear to me to be so, with the darker portion toward the center of the body of the sun, and the others appear round. Now I do not believe that they appear this way to me only, for I have shown it to others; nor do I believe that they are imperfections in the telescope, because I see them of various shapes, round and oblong; nor do I think that they are a group of stars, because in making a circuit they do not leave a space between themselves and the solar body. But the thing that confuses me is that the darker side is toward the center of the solar body; however, this not being "food for my teeth", I leave it for you to think about.

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* *Gal. Op.* **11**, 286.

† Grienberger believed that the spots were planetary bodies, which when off the disk would show "phases" like the moon.

This appearance of the spots, with the darker side towards the center of the disk, was also noticed by Scheiner who, either possessing a better telescope or better eyesight, reasoned that it was caused by the depth or thickness of the spots. It was later observed by Wilson of Glasgow in 1774, who in consequence announced his famous "depression" theory of the spots.

The "26 observations" referred to by Cigoli, are a series of drawings accompanying the letter and showing the appearance of the spots. The series commences with the 18th of February, and continues to the 23rd of March. The drawings show no details, but the progressive movement of the spots and groups across the disk is readily apparent.

Closely allied with the questions concerning the nature of the spots, was that of the sun's rotation. As will subsequently be seen, Fabricius preceded Galileo in actual time in publishing his belief in this fact, but he stated his conclusions very guardedly. It appears that Galileo's first explicit mention of his belief in the sun's rotation is contained in a reply to the letters of Cigoli mentioned above. This reply is dated October 1st 1611; Galileo writes:*

> I am glad that Sr. Passignano continues observing the sun and its revolution, but it is necessary that you should tell him that the part of the sun which is lowest when rising is highest when setting, whence it might appear to him on account of this that the sun had some other revolution in its place beside that which I really believe that it has, and which I think can be observed by the changes of the spots.

To this might be added, that the suspicion "whether the sun revolves in its place" had been expressed in the first edition of the *Discorso* which was finished at about this time.

In the first letter to Welser, having given his reasons for not believing that the spots are wandering stars between the earth and the sun, visible only when transiting the disk, which views were held by Apelles, Galileo expresses his belief in the rotation of the sun and the solar nature of the spots as follows:†

> I do not believe that they are either fixed or wandering stars, nor do I believe that they move around the sun in separate circles at a distance from it; and if I were to state my opinion in confidence to a friend and patron, I should say that the solar spots are produced and dissolved at the surface of the sun, and that they are contiguous to it; and that this same sun revolving in its place in about a lunar month carries them with it, and perhaps bringing back some one of them which has endured longer than the time of the sun's rotation, but so changed in appearance and surroundings as to be scarcely recognizable.

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* *Gal. Op.* **11**, 214.

† *Gal Op.* **5**, 111.

The successive observations having confirmed Galileo in the opinions which were at first hesitatingly expressed, he reiterates his conclusions and the reasons for holding them at the beginning of the second letter to Welser.*

The dark spots, which are seen with the telescope on the disk of the sun, are not far distant from it but are contiguous to it, or are separated by such a small interval that it is imperceptible. Moreover they are not stars or other solid bodies of long duration, for continually some are being produced and others are being dissolved; some being of short duration as 1, 2, or 3 days, and others of longer duration as 10, 15 days, and I believe others of 30, or 40 days or more. They are mostly of irregular figure and they change shape continuously, some with rapid and large changes, others more slowly and with less variation; moreover they increase and decrease in density, some appearing to condense and at other times to become rarified and diffuse; and besides changing into various shapes, one may be seen to divide into 3 or 4, and often many are united into one, which happens more frequently near the circumference of the solar disk than near the middle. Besides these irregular and individual motions of uniting and separating, condensing and changing figure, they have a maximum, common and universal movement, with which uniformly and in parallel lines they move over the body of the sun; from the peculiarities of this movement it becomes known, first, that the sun is absolutely spherical, second, that the sun revolves on itself about its center bearing the spots with it in parallel circles and completing its revolution in about a lunar month, with a revolution similar to that of the orbs of the planets, namely, from west to east. Moreover, it is to be noted that the majority of the spots seem to occur always in the same region or zone of the solar body, comprised between two circles corresponding to those which include the declinations of the planets, and beyond these limits as yet not a single spot has been observed, but all between these confines; so that neither towards the north nor towards the south do they appear to depart from the great circle of the sun's rotation more than about 28° or 29°...... The fact that we see them all moving as a whole with a common and universal movement is a sure argument that this movement can have only one cause, and not that each one of them is going around the body of the sun like a small planet at different distances and in different circles. Hence, we must necessarily conclude, either that they are all in a single sphere and like the stars are carried around the sun, or that they are in the body of the sun itself which revolves in its place and carries them with it. Of which two suppositions, the second appears to me to be true, the other false.

And later in the same letter, after giving numerous arguments and proofs, he continues:†

From the things thus far mentioned, it seems to me, if I am not mistaken, that the necessary conclusion is that the solar spots are contiguous or very near to the body of the sun; they are objects which are not permanent or fixed, but variable in figure and darkness......and their motion around the sun is manifest and indubitable. But to determine whether this results because the body of the sun itself rotates and turns in its place carrying the spots with it, or because the solar body remains fixed while the surrounding medium is in motion taking the spots with

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* *Gal. Op.* **5**, 116.

† *Gal. Op.* **5**, 133.

> it remains in a certain way doubtful, being perhaps the former or the latter. However, it seems to me more probable that the movement is of the solar globe rather than the surrounding medium. And I am led to believe this, first, because of the certainty that I have that the surrounding medium is fluid, thin and yielding; from the fact that the solar spots contained in it are seen so easily to change their shape, to coalesce and separate, which things could not take place in a solid and consistent medium (a proposition which will seem quite new to the common philosophy). Now a consistent and regular movement, such as is common to all the spots would not seem to have its cause and origin in a fluid substance composed of parts which are not coherent, and are hence subject to commotion and disturbance by many accidental movements, but rather in a solid and consistent body where there is of necessity a single motion of the whole and of its parts, and it is believed that such is the solar body in comparison with its surroundings. Such a movement would then be imparted to the surrounding medium by contact, and to the spots by the medium, or imparted directly to the spots by contact and would carry them about.

In the third letter to Welser, written on December 1, 1612, Galileo supports his former conclusions regarding the movement of the sun with the additional evidence obtained from the motion of the faculae, which are here described for the first time: †

> I hope that Apelles will be satisfied with what I have said to date, especially when he reads what I wrote in the second letter, and I believe that he will have no objection to make, not only to the great nearness of the spots to the solar globe, but also to its revolution about itself; in confirmation of which I add to the arguments that I gave in the second letter to you. In the face of the sun itself there are sometimes seen certain small regions which are brighter than the rest, which when diligently observed show the same movements as the spots; and I believe that no one can doubt the fact that these are in the sun itself, it not being creditable that outside of the sun there should be found any substance more luminous than itself; and if this be so, it does not seem to me that there should be any more reason for doubting the revolution of the solar globe. And such is the connection of the truths, that it follows in a similar manner that the spots are contiguous to the surface of the sun and are carried around by its revolution; no plausible reason appearing why these (if they were separated from the sun by much space) should follow its revolution.

Possibly Galileo was influenced by the letters of Passignano and Cigoli while pondering on the problem of the solar spots, but how much this influence amounted to we do not know. At any rate the force of Passignano's argument of the varying speed of the spots as they traversed the disk must have appealed to Galileo and helped to strengthen his opinion that the spots were a part of the sun itself, or at least must be very near its surface. He makes use of this argument many times in the letters to Welser, where he mentions the varying speed of the spots, the changes in their apparent distance from each other, the changes in the apparent dimensions and appearance of the spots near the center and the edge as they transit the disk; explaining each with great detail and clearness, and concluding with the statement that these are phenomena which "could not be met with in any other but the circular motion made by divers points variously placed upon a globe which revolves upon its own axis."

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† *Gal. Op.* 5, 219.

These extracts from the writings of Galileo have been quoted, notwithstanding their length, because it is believed that they are essential in order to demonstrate how the idea of the sun's rotation arose and developed in his mind; and passing through many uncertain stages, gradually crystallized into a definite form. The statements which have been quoted, and the many more scattered through the letters to Welser, show clearly, however, that whatever hints Galileo may have received from the letters of such as Cigoli and Passignano, he far surpassed them, and utilizing to its fullest advantage every phenomenon of the motions, changes, etc., of the spots, formulated a theory of their motion regarding which there could be no further discussion.

It is quite certain that at the first Galileo believed that the axis of the sun's rotation was perpendicular to the plane of the ecliptic. This is mentioned in the third letter to Welser;* however, he afterward changed this opinion. But this will be discussed in more detail later.

The subsequent history of Galileo's observations of the solar spots is so involved with the history of Scheiner's investigations and with the quarrel between them for priority of discovery, that the subject will be discussed with Scheiner's observations in a later portion of this paper.

(To be continued.)

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* *Gal. Op.* 5, 189.

THE TABLE OF ZEUS.

By Ptolemy the Astronomer.

"I am mortal—the thing of a day; I
know it. And yet when I trace
The stars in their spirals and rings,
as they turn and return overhead,

My feet are no more upon earth; I sit
down in the heavenly place;
I partake at the table of Zeus of the
food of the gods; and am fed."

[Translated from the Greek by an Oxford Scholar.]

REPORT ON MARS, No. 14.

WILLIAM H. PICKERING.

THE TWO VARIETIES OF CANALS.

As a result of the observations made at the last opposition, that of 1913-4, it is concluded that the dark areas on Mars, whether broad areas like the maria, or narrow ones like the canals, are of two distinct classes, those that are comparatively permanent, and those that are ephemeral. Soon after the northern polar snows began to melt, the cap was surrounded by a broad grey or brownish band, that, unlike the southern maria, never appeared green. It soon narrowed in places to a mere canal, bounding the cap on the south. This canal retreated towards the north with the snow, and as compared with many of the more southern features of the planet was distinctly ephemeral. The polar bays, of which there were four that year, all exhibited a similar shifting, but their deep blue color, at times, indicated water. All these shifting dark areas are believed to owe their darkness either to ground moistened by thawing, or to actual swamp. The darkness of the more permanent canals and green maria are thought to be due to vegetation.

To illustrate the difference between those two kinds of canals Table I has been prepared. The left hand side of the Table represents the best drawing made each day during the presentation of the planet preceding opposition, the other side the drawings of the presentation following, the two sides being arranged exactly alike. The first two columns give the date and longitude of the central meridian, the next the number of canals shown on each side of the meridian, the *P* indicating the preceding or eastern side. The last column indicates by a cross on which side of the meridian the polar band was most marked, as indicated either by its breadth or density, or both. When there is no choice between the two sides, the result is entered under the column headed *E*. The four polar marshes are not included in this estimate, each balancing off an equal length of canal, on the other side. Prior to opposition the limb is on the *F* side, after opposition on that of *P*. The subscripts $_l$ and $_t$ stand for limb and terminator.

With regard to the permanent canals, we find that in general both before and after opposition, six-tenths of them are found on the side of

TABLE I.

PERMANENT AND EPHEMERAL CANALS.

Before Date	ω	Permanent		Ephemeral			After Date	ω	Permanent		Ephemeral		
		P_t	F_l	P_t	E	F_l			P_l	F_t	P_l	E	F_t
Dec. 3	346°	0	1		+		Jan. 6	351°	1	0	+		
8	306	0	0	+			10	342	3	0	+		
10	273	4	1	+			12	338	2	2		+	
12	252	4	2	+			15	281	3	0	+		
13	237	3	3	+			17	284	5	0	+		
15	227	3	5		+		18	240	6	4	+		
16	192	2	4			+	20	222	7	5		+	
17	185	2	7		+		21	184	1	1		+	
18	177	0	6		+		27	163	0	1	+		
19	162	1	3		+		Feb. 1	158	1	4	+		
22	168	2	2	+			5	104	4	3		+	
23	172	2	5		+		7	75	3	1		+	
25	125	6	0		+		8	42	1	1	+		
29	155	1	2	+			10	50	0	2		+	
30	101	6	2		+								
31	64	5	5		+								
Jan. 4	5	1	2		+								
5	41	0	3		+								
Total		43	53	6	11	1			37	24	8	6	0
Per cent		45	55	33	61	6			61	39	57	43	0

the planet towards the limb. This side has slightly the greater area, and it is also rather better lighted. On the whole the preceding, that is the afternoon, side of the disk shows a slight excess of canals over the morning side, 80 to 77, but not more than might well be due to accident, on account of the small number of observations considered. For the ephemeral canals on the other hand, those that we have attributed to marshy conditions, we find that before opposition on 33 per cent of the dates they were most marked in the afternoon or preceding side, to only 6 per cent in the morning. After opposition, as the sun rose higher upon them, with the advance of the season, 57 per cent of the dates were most marked in the afternoon, and none at all in the morning. It therefore appears that the permanent canals are most marked on the limb side, and the ephemeral canals on the side when it is afternoon, regardless of limb or terminator. Indeed by watching the polar band, and estimating its breadth in a given longitude with regard to the breadth of the polar cap, we should actually be able to see the ground on Mars thaw out under the influence of our sun as the Martian day progresses. This has in fact been done here this past month on several occasions, a difference being noticeable in the course of two or three hours. This, and watching the fog clear and shift on the sunrise limb, brings before us rather vividly the meteorological conditions existing on our sister world.

But it is not only at the boundary of the snow that the ephemeral canals and swamps exist. Sometimes these canals lead away from the snow with a slightly southerly inclination. Again while the canal usually retreats with the snow, yet sometimes it is left behind and a fresh canal develops between it and the snow cap. Thus on December 10, 1913, the boundary canal was narrow and was clearly identified as Heliconius. On the 12th the snow had retreated somewhat to the north, and the canal was very broad and light blue in color. On the 13th it had again narrowed, and shifted towards the further retreating snow. On December 15 the snow had still further retreated, and the canal was now very narrow and clearly coincided with Pyramus. A month later on January 17 Heliconius was very faintly indicated, with Pyramus clearly marked to the north of it.

The Syrtis marsh is another example of an ephemeral dark area. The lakes and canals seen in the Protei region, described in Report No. 3 and figured in No. 8, are clearly examples of ephemeral markings, very different from the usual run of canals and lakes. That a lake or swamp 1000 miles in length, as shown in Report No. 8, Figure 22, should exist where nothing of the sort was seen four days previously, as shown in Figure 23, appears to us as little short of astounding. Similarly that the Protei lakes 200 and 300 miles in diameter should disappear in the course of a few days seems to us well nigh incredible. Clearly they must all have been very shallow bodies of water or mere marshes, and the surface of Mars in these regions must be very flat. If consisting of marshy land the marshes are not necessarily all at the same level, and might even be intersected by small ranges of hills, invisible to us. Nevertheless, such changes are certainly extraordinary and never occur upon either the Earth or Moon, the only other planetary bodies with those surfaces we are familiar. If due to the presence of water however, such changes are exactly what we should expect to find on Mars. Indeed had we known that the surface was so level, we might almost have predicted them.

The explanation is comparatively simple, and depends merely on the atmospheric pressure. On the Earth the pressure is so great that the boiling point of water is raised far above the mean temperature of the planet. Consequently evaporation and precipitation both take place slowly. On the moon the pressure is so low that the boiling point would be reduced to the melting point, and consequently water as such disappears entirely from the surface. Imagine now a planet with an intermediate atmospheric pressure. Let us suppose the boiling point reduced to the mean temperature of the planet. Steam would therefore rapidly condense to water at night, and the water would boil away by day into steam. Judged by appearances it would seem that on Mars the boiling point is slightly but not far above the daylight temperature. Otherwise we should expect the marshy areas to be continually enveloped in cloud. This is not the case, although heavy clouds are often seen rising from them (Reports Nos. 3 and 4).

If the daylight temperature of Mars were 68° *F* (20° *C*), in order that water should exist on its surface, the pressure of its atmosphere would have to be at least five-eighths of an inch (17 mm). It is generally supposed to lie between one and three inches. Writers sometimes commiserate with the Martians for not having more water on their planet, but it would seem that they may perhaps thank their lucky stars that there is not more of it, else they might all be in danger of drowning! While it now appears improbable to us that the canals are devices for transporting water across the surface of the planet, it is possible that some of them may serve the opposite purpose, that of retaining the water as long as possible, so that all may not be carried at once to the other pole, by means of the regular aerial planetary circulation.

PERMANENT CHANGES OF SURFACE.

In Report No. 7 we showed by means of a series of drawings the gradual changes that had taken place in that region of the planet following the Syrtis during the past thirty-six years. What is in some ways a more striking and interesting change is exhibited by the drawings in Plate II. The first observer to represent the surface of Mars completely and accurately as we know it today was Sir J. N. Lockyer, in 1862. He employed an aperture of 6 inches. Other early observers show certain features, notably the Syrtis itself, which can be readily identified at the present time, but most of their drawings show little else that is now recognizable, and the drawings themselves are clearly of but little value.

There are two features shown by Lockyer however that at once strike the modern observer as peculiar. If we examine his drawing, Figure 3, and compare it with Schiaparelli's map in our first Report, we shall recognize without difficulty Sabaeus on the extreme left and Solis Lacus on the right. South of Solis we shall recognize Tithonius, and note where it is joined to Aurorae, but what is that singular marking which fills the place now held by Juventae Fons? For convenience we will call it *X* and shall refer to it by that name hereafter. Starting now from Sabaeus and proceeding towards the center of the disk we first reach Margaritifer, and soon after its twin feature, another unrecognizable marking, which we will call *Y*. It will be noticed that while Lockyer does not show the point of Aryn, he does show Sigaeus

PLATE II

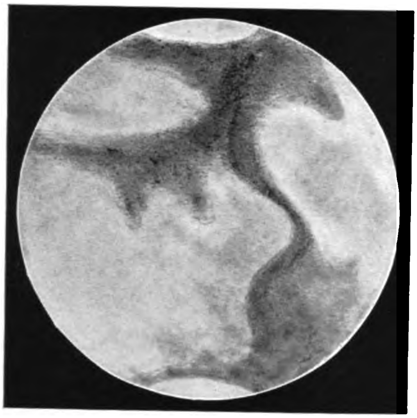


FIG. 1.
Secchi
1858 June 5, $9^{h}40^{m}$

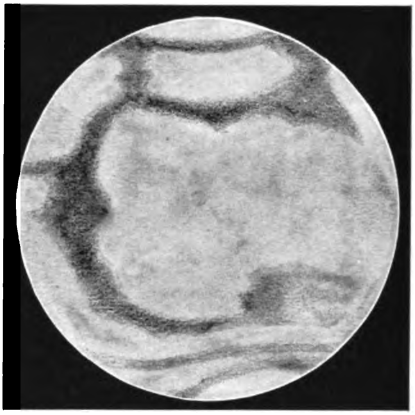


FIG. 2.
Secchi
1858 June 10, $9^{h}00^{m}$

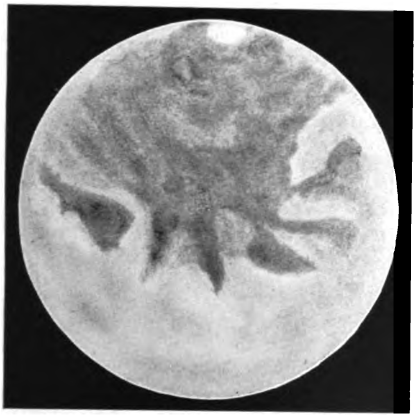


FIG. 3.
Lockyer
1862 Sept. 23, $12^{h}55^{m}$

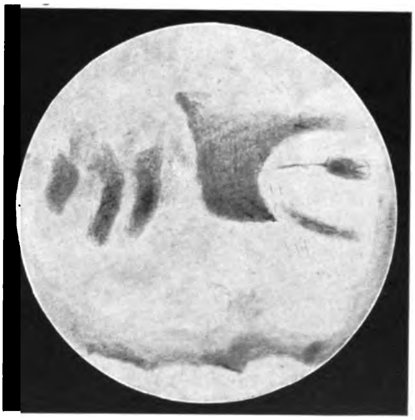


FIG. 4.
Kaiser
1864 Dec. 18, $10^{h}00^{m}$

DRAWINGS OF MARS

Portus, the little bay where Phison and Euphrates join Sabaeus, also Daradax, the bay lying between it and the forked bay of Sabaeus. These are both very minute details, often not visible at the present day. They indicate the general accuracy of his drawing, and our surprise is the greater at the presence of the large unfamiliar markings *X* and *Y*.

Figure 4 is by Kaiser, drawn two years later. Aperture 7 inches. *X* does not appear on his drawing and the region looks much as it does at the present day (see Report No. 8, Figures 5 to 8) but *Y* is clearly shown, and equals Margaritifer in size. Sabaeus appears at the extreme left.

Figure 5 is by Dawes. Aperture 8 inches. He had a keen eye, and discovered the point of Aryn within the forked bay, which was formerly named after him. His sense of proportion was not good however, and he brings the bay much too near to Solis Lacus. He does not show *X*, but *Y* is even more prominent than in the previous drawings.

In Figure 6 Green, who was an artist by profession, and who necessarily had an excellent idea of proportion, represents this region very much as did Lockyer and Kaiser. He used a reflector of 13 inches aperture. Sabaeus is on the extreme left, and Solis on the right. He shows *X* quite as clearly as did Lockyer, although of a somewhat different shape, but of *Y* there is no sign whatever. That part of the drawing might have been made yesterday.

The drawing by Schiaparelli shown in Figure 7 aperture 18 inches, differs from our modern drawings only in the fact that the promontory to the right of Margaritifer extends much farther south than it does at present, or in Kaiser's or Green's drawings. There is no trace of either *X* or *Y*,—except as canals.

If we turn back to Secchi's drawing made in 1858, aperture 9.5 inches, Figure 2 is readily recognized with the Syrtis on the left, the forked bay of Sabaeus on the right and Sigaeus Portus, longitude 335° on the central meridian. Compare with Report No. 8, Figure 4. In Figure 1 computation shows that longitude 35° must therefore have been central much as in Figure 3, and it is clear that the three bays indicated must be Margaritifer, *Y* and *X*, the latter connecting, through Ganges with Acidalium, much as Aurorae did in 1913-4. Compare with Report No. 8, Figure 9. Secchi's representation of *X* is more like that of Green than it is like that of Lockyer, but it is clear that the same object was seen by all three.

We thus find *X* shown on three of these early drawings, and *Y* on four of them, in fact on all four of the earliest ones, drawn prior to 1865. Considering the general accuracy of these drawings even in minute details, we can hardly doubt that large dark areas on the planet have therefore really permanently disappeared in the past fifty years. This it will be noted is quite a different matter from the extensive temporary changes that are now generally recognized as occurring upon the planet. In general the length of both *X* and *Y* may be taken at 500 miles. To adopt a terrestrial analogy it is much as if the group of the New England States had been converted into a permanent desert, or as if the same thing had happened to England and Scotland. These drawings are all taken from Flammarion I, 138, 139, 153, 177, 186, 278 and 475.

It is not easy to determine the exact date at which the *X* and *Y* markings disappeared from Mars. This is because the drawings made between 1864 and 1877 are of inferior quality to those that preceded and followed them, perhaps owing in part to the greater distance of the planet at opposition. According to Burton in 1871 the *Y* was still there. According to Green in 1873 its existence is doubtful, while Terby indicates plainly that it was not visible. In October 1877 Dreyer shows it on a drawing, while Green as we have already seen clearly indicates that in September it had disappeared. If we neglect Dreyer's drawing, it disappeared between 1871 and 1873. The evidence regarding the *X* is unsatisfactory. As we have seen, its location is now marked more or less by Juventae Fons. According to Schiaparelli the longitude of Juventae in 1877 was 61°, in 1888 it was 64°. In 1879 Lohse made it 68°. According to drawings by Professor Douglass, Mr. Slipher and the writer in 1914 (Report No. 8) its longitude was 52°, 68°, and 52°. We have here a total range of 16°, but since on Mr. Slipher's drawing Juventae is nearer the limb than on the others, we may accord his drawing half weight, and obtain a mean value of 55°. This compared with the mean of the three earlier values 64°, gives a range of 9° or over 300 miles! Clearly the longitude of this marking should be investigated.

The last drawing, Figure 8, is from an unpublished sketch made by Professor Douglass while at Arequipa in 1892. It is of interest as showing how the promontory to the right of Margaritifer, which Schiaparelli showed extending so far to the south, changed back to its present abbreviated form. It was not by a gradual shortening, as we might have naturally expected, but instead, a dark band stretched straight across it from east to west, cutting off the tip. This band was very dark and conspicuous, and is shown on a number of Professor Douglass' drawings, as well as on several others made at the same time by the writer. The region to the south of it later darkened. As far as known this band has never since been seen in the dark and distinct form that it had during that opposition.

Another striking fact which these earlier drawings impress upon us is the general tendency on Mars to duplication, and also to the produc-

PLATE III

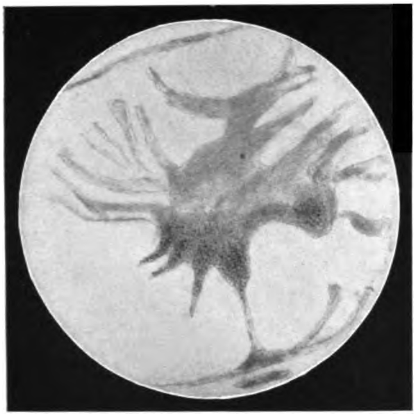


Fig. 5.
Dawes
1864 Nov. 14, $12^{h}00^{m}$

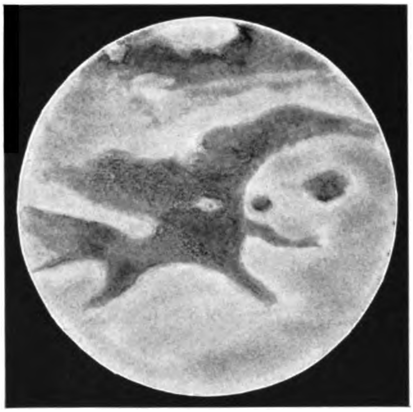


Fig. 6.
Green
1877 Sept. 1, $13^{h}10^{m}$

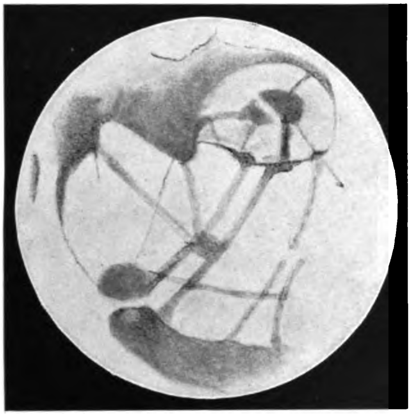


Fig. 7.
Schiaparelli
1890 June 9.

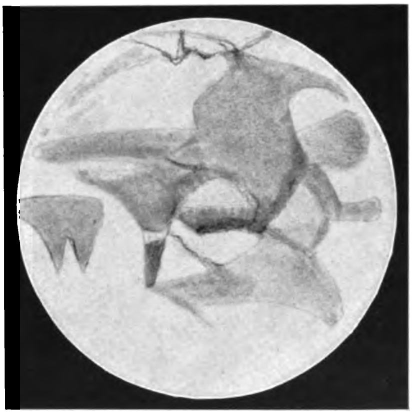


Fig. 8.
Douglass
1892 Aug. 15, $10^{h}40^{m}$

Drawings of Mars

tion of triangular bays. The latest instance of this occurred at the last opposition, when Propontis and Castorius suddenly appeared side by side and just alike (Report No. 4, Figure 1). The forked bay of Sabaeus is another instance, and now we have Margaritifer, and its twin *Y*. On the earth the only well marked triangular bays or straits are the Gulf of California, the Straits of Malacca, and the northern end of the sea of Japan. That six such bays should have been seen on Mars, grouped in three pairs, indicates that there must be some connection between the components. Since the *Y* has long since disappeared, it seems that it is not necessary that the connection should be maintained.

That Propontis and Castorius exactly coincided in position with the canals Hades and Erigone on Antoniadi's map (Flammarion II), leads us to surmise that the frequently recorded duplication of the canals may also be a genuine phenomenon. The difficulty that the writer has always felt regarding it, however, has been that those who saw it, either saw too much, or else other observers saw too little. We have seen by Report No. 11 that one felt uncertain of the separation of two parallel lines with the naked eye when the angular distance between them was reduced to 69″. Schiaparelli discovered the duplication of the canals with an aperture of 8 inches, and it is claimed to have been seen with 6. If the diameter of the pupil of the eye is assumed under ordinary conditions in a well lighted room to be one-eighth of an inch, as for instance when the above recorded separation of the parallel lines was suspected, the separation of the canals when observed with these small apertures should range from at least 1″ to 1″.33. That such obvious separations should not be readily detected with larger apertures, working even under rather unfavorable atmospheric conditions, seems incredible. On account of the lateness of the development of the detail on Mars this season, the assumed duplication will hardly reach its maximum before opposition, so that this year should be extremely favorable for its detection, if it really exists.

Observations in December.

Early in December the deserts were very red, and on the 6th and 10th they were painted to match 14 on the scale. By December 14 they were orange and matched 12. On December 17 and 19 they were still more yellow, with scarcely any cloud visible at the limb. Their color must nearly have reached 11. The next night the disk was seen at a glance to be much redder again, with much cloud on the limb, and also scattered in small areas over the disk. The reading on the color scale was found to be 14. December 25 the color was reduced to 12.5. It thus appears that while the bands that later develop into canals are still broad, and while the main features, such as the bays of Sabaeus and

Margaritifer, are still in the process of forming, the atmosphere of Mars is generally in a pretty hazy condition. It is only when the atmosphere clears that the individual clouds become distinctly visible. While the scale is particularly adapted to the determination of the general color of the desert regions, and their variation from night to night, in order to determine the colors of the individual markings, such as the maria, and the blue and brown spots, another method must be employed. This consists in actually drawing and coloring the disk, and viewing the result through a black mask by a properly colored light. When this has been done, it is found that the maria are not in general really green by white light as our vegetation is, but only grey. That is they match plain pencil shading. On the other hand however, they are decidedly green compared with the desert regions. We therefore conclude that the vegetation is not continuous as with us, but occurs in spots on the red soil, the red and green uniting to produce on our eyes the effect of grey. The northern maria, which we have hitherto described as grey, it now appears have a brownish tint, doubtless that of moistened soil. Observations were secured upon the following dates:—

December 4, ω 173°, M. D. March 46. Owing to previous unfavorable terrestrial atmospheric conditions at this Martian longitude, this was our first view this year of the twin bays of Propontis and Castorius. They were now united into one broad and nearly uniform band, extending from the polar cap to Charontis.

December 6, ω 153° and 190°, M. D. March 48. The individual canals leading from the two bays to Charontis were now just visible, and quite distinct, but the bays themselves were still combined into one. Titanum was distinguishable, but not yet very marked in shape. Definition good, but very little detail.

December 7, ω 174°, M. D. March 49. A cloud 700 miles in length following Charontis was noted within 30° of the central meridian. Earlier it also followed the western canal connecting Charontis with the polar band. The breadth of this band, where preceding Propontis, in longitude 140°, was recorded as follows, in terms of the breadth of the polar cap, showing its gradual broadening as the Martian day progressed. The

TABLE II.

BREADTH OF THE POLAR BAND.

G. M. T.	ω	M. L. T.	Breadth	Miles
h	°	h		
20.7	145	2.6	0.6	300
21.0	150	2.9	0.7	350
22.6	172	4.5	0.8	400
22.8	175	4.7	0.9	450
23.0	178	4.9	1.2	600

third column of the table gives the Martian local solar time for longitude 140°. The rapid increase in breadth towards the end of the observation was in large part due to the proximity of the terminator, which caused the whole region to darken. The four earlier observations are believed to be fairly accurate. The latitude was + 55°.

December 8. The longitude and latitude of the south preceding corner of Castorius were determined, by the method described in Report No. 13 at the time of transitting the central meridian, at 135°.6 and + 43°.

December 10, ω 118°, M. D. March 52. The longitude and latitude of this point were redetermined. Result 137°.5 and + 43°. It will be interesting to see if the longitude increases as the season advances. The latitude was certainly greater than + 39°. It was at first thought that the twin polar bays had begun to separate, but it was concluded later that the effect was only due to a cloud stretching across the dark region. Phoenicis Lacus was faintly seen for the first time this year.

December 14, at ω 72° Solis Lacus was near the central meridian. It had clearly developed, but the seeing was too poor to draw it satifactorily.

December 16, ω 64°, M. D. April 2. The rounding off of the following end of the polar cap towards the limb was distinctly seen for the first time, although the cap still appeared tangent to the limb. A minute cloud was suspected following the Acidalium marsh, and past the central meridian. That is it had lasted well into the Martian afternoon. Solis Lacus could not be distinguished.

December 17, ω 83°, M. D. April 3. The snow cap had materially increased in size. Tithonius and Solis had now both developed.

December 19, ω 66°, M. D. April 5. A very brilliant white area was seen on the southern terminator, just preceding Thaumasia. It appeared whiter and fully as bright as the northern cap. Its latitude was in the vicinity of − 40°. It seems at first rather early for snow in the southern hemisphere, until we look at the calendar and find that it was 61 days after the equinox in their long winter season. Since it was seen just before their sunset, it does not seem likely to have been hoar frost, but as it was not found again the next night, it must have been a very thin layer of snow.

December 20, ω 33°, M. D. April 6. The striking change in color of the disk due to the clearing away of the Martian clouds has already been described. The Acidalium marsh was found to have largely increased in size, its meridional length was now 1000 miles, in place of 600 as on the previous night, and its breadth 800 instead of 600. It was darkest towards the snow, and its color was bluish black. The conspicuous canal Hydraotes visible the previous night had disappeared and its place was covered by a white cloud, although it was now as late as two in the afternoon by Martian time in that longitude. Three drawings were made of the snow cap, measuring 16, 15, and 14 millimeters in length. The first and last were obviously too large and too small, indicating that we should expect an accuracy of about one millimeter, or 0″.25, that being the scale on which all our drawings are now made.

December 25, ω 353°, M. D. April 11. The color of the deserts had again assumed an orange tint, indicating that the clearing off observed December 20 was but temporary. Although the Acidalium marsh was distinctly blue, there was no trace of polarization that could be detected. This is unusual, since the blue color and polarization usually go together. The snow cap which had somewhat diminished December 23 had again increased in size. The bay of Sabaeus had begun to develop, although there was no trace of Aryn as yet. Seeing 7. This date is 24 days later than any of the drawings showing Aryn published in Report No. 8. The region which should later develop into the Strait of Sabaeus had narrowed appreciably since our last previous view of it November 19, but the southern boundary was not sharply defined as yet. There was no trace of Margaritifer, although five days earlier a slight projection in that place had been recognized. The broad straight band connecting Acidalium with the Bay of Sabaeus appeared much as it did in November. Except Deuteronilus and Callirrhoe previously recorded, no canals were visible.

It will be recalled that in Report No. 12, on October 23, M.D. March 5, mention is made of the first appearance and formation of the Syrtis marsh this Martian year. On November 19 to 27, M. D. March 32 to 40, it was well seen, but it then appeared not much darker than the surrounding region, and only of moderate size. On December 26, M. D. April 12. At ω 300° the straight band connecting the Syrtis with the polar cap was clearly seen, and it was recorded that the Syrtis might be a little darker at the tip, but certainly there was no extensive marsh there at that time. Seeing 5. With this quality of seeing magnification 330 was clearly preferable to 660. A report has just been received from Professor Douglass of the Associated Observers, who observed it on the nights of November 26 and December 2. He states that the Syrtis seemed to show pretty black in its northern part in a limited area, especially on the second morning, but it did not show at all until within 30° of the central meridian,—"as if emerging from a morning fog." His drawings show a comparatively small dark region about 300 miles in diameter. Neither observer had hitherto detected any blue color in it, and it is doubtful if it contained much water up to

December 26. Professor Douglass' observation corroborates the view that there is still much fog in the Martian atmosphere.

Owing in part to unfavorable atmospheric conditions, and in part to circumstances over which the writer had no control, it was impossible to secure any observations on the last five days of the month. As soon as the telescope was again turned on the planet, January 1, it was at once noted that the Syrtis marsh was strongly developed, of large size and very blue, especially on the preceding side. The southern border was indistinct, but it was evident that a considerable change had occurred since our last observation. Its length and breadth on its southern border were both about 1200 miles. It is to be hoped that the planet has been under observation elsewhere during these five days, and that some one of the Associated Observers will be able to give a detailed account of just what happened, and especially of when the blue color made its first appearance. Three observations and a colored sketch have been sent by Mr. L. J. Wilson, S. P. A. The latter, made upon December 5, ω 135°, shows the Propontis Castorius region as slightly developed and of a bluish color. There is a small cloud on the southern terminator. Extensive color observations have been received from Mr. McEwen made on the nights of October 14, 21, and 30. The second indicated a darkening to the west of the Propontis region, at the edge of the polar cap, near longitude 200°. He also noted a bright area (presumably a cloud) following Charontis. The usual cloud following the Acidalium marsh was recorded in the last observation. He also recorded Tithonius, Ascraeus, Lunae, and Phoenices lakes. Ceraunius was recognized, and suspected of duplicity.

A very interesting private letter has just been received from M. Jarry Desloges, which unfortunately I am not permitted to quote. A few statements of general interest may be culled from it however. He says that although he possesses a telescope of 20 inches aperture, he considers that for planetary work it is useless to use apertures exceeding 13 inches, nor does he favor higher magnifications than 500. He states that excellent atmospheric conditions are found at Setif in northern Africa in the winter time. The altitude is 3600 feet, and two years ago they had 60 inches of snow there for over a month. This statement is of particular interest, since at nearly all the chief observatories of the world, north and south of the equator, the weather is unfavorable during the northern winter months. He carried a large telescope into the desert some 200 miles from the coast but found the conditions there distinctly inferior to those at Setif. This fully confirms our experience in Jamaica, that our best seeing comes on damp nights. He does not agree with the writer and some others that Elysium appeared rounded at the last opposition. An observation by the writer made early in January indicates a considerable change in size in Elysium, and it is hoped that others will devote especial attention to this marking this year. Those sending colored sketches to the writer should mention the source of light they employ, and also mention if they took the precaution to have the image of the planet and the drawing of the same brightness.

Table III contains the usual data of the month's drawings.

TABLE III.

DATA OF THE DRAWINGS.

No.	1915	⊙	M. D.	Long.	Lat.	Sun	Diam.	Seeing
31	Dec. 4	22°.4	Mar. 46	173°	+20°	+9°	9″.0	6
32	" 6	23.3	" 48	153	"	"	9.1	8
33	" "	"	" "	190	"	"	"	8
34	" 7	23.8	" 49	153	"	"	9.2	7
35	" "	"	" "	174	"	"	"	6
36	" 10	25.2	" 52	118	"	10	9.5	12
37	" 16	27.9	Apr. 2	64	"	11	10.0	7
38	" 17	28.4	" 3	83	"	"	10.1	7, 6
39	" 19	29.3	" 5	66	"	12	10.3	8, 7
40	" 20	29.8	" 6	33	"	"	10.4	9
41	" 25	31.9	" 11	353	"	"	10.9	7, 6

The following canals and lakes were seen:—

Dec.	4	D	Cerberus. Lakes: Charontis.
Dec.	6	D	Cerberus, Hades, Erigone (Antoniadi). Lakes: Charontis.
Dec.	7	D	Cerberus, Hades, Erigone (A), Titan. Lakes: Charontis.
Dec.	10	C	Phlegethon, Acheron, Pyriphlegethon (?) Lakes: Phoenicis.
Dec.	16	B	Nilokeras, Chrysorrhoas, Hydraotes, Jamuna, Ceraunius. Lakes: Lunae, Tithonius.
Dec.	17	B	Ceraunius, Nectar. Lakes: Lunae, Tithonius, Solis.
Dec.	19	B	Nilokeras, Hydraotes, Chrysorrhoas, Araxes, Nectar. Lakes: Lunae, Tithonius, Solis.
Dec.	20	B	Nilokeras, Chrysorrhoas.
Dec.	25	A	Deuteronilus, Callirrhoe.

CELESTIAL MOTIONS IN THE LINE OF SIGHT.

RUSSELL SULLIVAN.

The spectroscopic study of stellar motion in the line of sight (i.e. the line connecting the star to the observer) has of late made tremendous strides. Although it has been known for some years that stars of advanced spectral type move more swiftly than the earlier types, yet it is only within the last year or two that these studies have been applied with success to the nebulae.

Commencing the scale of cosmic speeds with the great nebula in Orion, we see an increasing series of velocities, as is evident from a glance at the table given below. There is a gap between the type "M" stars and the Planetary Nebulae, although this may be filled by a class of faint swift stars which Eddington has recently described. (The latter have not been investigated spectroscopically). The other gap lies between the Planetary Nebulae and the Spiral Nebulae which have recently been found by Slipher to possess enormous radial velocities. There seems to be no evolutionary step between the spirals and the planetary nebulae, whereas, from the slow type "B" star up to the planetary nebulae there is a fairly continuous series of speeds.

Campbell found an uninterrupted progression of speed through the types B, A, F, G, K, M; the following table shows the progressive increase of cosmic velocity:

Table of Comparative Radial Velocities.

	Average in miles per second	
Great Nebula in Orion	0.66	Keeler
B	3.91	Campbell
A	6.57	"
F	8.62	"
G	8.98	"
K	10.08	"
M	10.26	"
Planetary Nebulae	30.00	"
Spiral Nebulae	240.00	Slipher

If the motion of the great nebula in Orion be represented by a line an inch long, the motion of the spiral nebulae would correspond to a line 30 feet in length.

The great nebula of Orion is generally assumed to represent the beginning of stellar evolution. It is gaseous and almost at rest in space.

Type "B" is the intensely luminous helium (or Orion) star; type "A" is exemplified by Sirius and is usually known as the hydrogen star; type "F" is the Calcium star; the sun belongs to type "G"; type "K" is similar to the solar type, but differs principally in having hydrogen lines fainter than the metallic lines; type "M" is well shown by the ruddy Betelgeuse in whose spectrum titanium oxide predominates—metallic lines and flutings characterize the latter types.

The distribution of the series B, A, F, G, K, M, is confined to the Galactic Plane for the slower types, but is almost globular for the faster types ending with type "M". The irregular and planetary nebulae tend to lie in or near the plane of the Milky Way, (the latter class so called because of their resemblance to the disk of a planet). Both types are gaseous but on account of the great difference in speed they appear to belong to opposite ends of the scale of evolution. The speed of the planetary nebulae argues a stellar origin for these bodies, as suggested by Campbell. The spirals belong to the non-gaseous type and give a continuous spectrum, implying the existence of solid matter or gas under great pressure.

The spirals tend to crowd towards the poles of the Milky Way. Slipher found that they belong to the G-K types of spectrum—similar to that of the sun, and rather late in the evolutionary scale.

The vast gap between the planetaries and the spirals almost tempts one to believe in the existence of a different cosmic order; before the spectroscope had shown the difference in nebulae, the majority of astronomers believed that the spirals were "island universes"; among recent writers, Poincaré, Puiseux, Russell and Eddington have suggested that the spirals are distant sidereal universes.

Recent measures of radial velocities by Ralph E. Wilson on the Lick Observatory plates on four gaseous nebulae in the Greater Magellanic Cloud indicate great and nearly equal speeds, and it is fair to assume that the Greater Cloud as a whole is in very rapid motion. Thus it is easier to credit the spiral nebulae with enormous velocities.

Slipher finds that the greater component of motion is parallel to the plane in which the arms of the spiral lie; so the spirals would tend to move edge-on through space, and appear to follow the line of least resistance. (The plane of the solar system exhibits a similar tendency to move edgewise through space, towards the sun's distant goal). Eddington and Easton think that the Milky Way includes the arms of a gigantic spiral and thus we can infer that our own universe is moving at great speed, as Poincaré has suggested, principally in the plane of the Milky Way; as the sun lies in or near the plane of the Milky Way, we are living in the nucleus of a spiral nebula.

Slipher's results also indicate that the spirals measured north of the Milky Way were receding at great speed, but south of the Milky Way, the few measured (with some exceptions) were approaching. Before noting the exceptions, he suggested that this was a drift of the spirals across the Milky Way from south to north; perhaps it can be interpreted as a drift of the Milky Way from north to south. Poincaré suggested that the spirals be observed for motions at right angles to the line of sight to detect a possible rotation of the Milky Way. This method would have taken centuries. It seems that his plan is being executed in a new and unexpected way.

The idea of external "island universes" as held by the older astronomers of the last century, is again in favor—this time with the spectroscopic evidence of speeds surpassing the wildest dreams of the old school.

THE MOTIONS OF THE SPIRAL NEBULAE.

O. H. TRUMAN.

I have lately been considerably concerned about the question as to whether the spiral nebulae are other sidereal universes. The admirable way in which that hypothesis would account for their vanishingly small parallaxes and proper motions, for their luminosity, and for their distribution in the sky makes it very attractive, and the only evidence against it, and that, I think, not conclusive, is the fact that some of them show pure, or almost pure, types of spectra.

Now if they are other sidereal systems, it seems likely that a distinct motion of our own spiral nebula with respect to them would manifest itself, and conversely, if we can find such a motion of our system with respect to the nebula, it will be quite strongly urged upon us that they are other sidereal systems. This has already been remarked upon by H. Spencer Jones. And inasmuch as we already have radial velocities of upwards of a dozen, in different parts of the sky, determined by V. M. Slipher and published in POPULAR ASTRONOMY, Vol. 23, page 23, January 1915, and Herschel discovered the solar motion with about that number of stars, it seems time to investigate.

So from that list I have taken N. G. C. 221 and N. G. C. 224, the Andromeda nebula and companion, as one nebula, as their equal radial velocities, — 300 km / sec, should remove any residual doubt that they belong together; N. G. C. 3031 and 4826, whose velocities Slipher gives as "Plus, small" I have given velocities of plus 100 km / sec; and N. G. C. 5195, whose velocity he gives as "± Small," I have given a velocity of zero. I do not know whether his velocities are corrected for solar motion or not, but the corrections would be comparatively insignificant, so that makes no difference in the results.

The list may now be solved out by least squares in the usual way, such as is described, for instance, in Campbell's "Stellar Motions," p. 170, and one obtains as the components of velocity of the center of position of the group:

$$x = -340 \text{ km / sec} \pm 145$$
$$y = +530 \text{ km / sec} \pm 320$$
$$z = +230 \text{ km / sec} \pm 190.$$

where, of course, x is in R. A. $0^h\ 0^m$, Dec. 0°, y in R. A. 6^h Dec. 0°, and z is at the north pole.

It appears that the ratios of the quantities determined to their probable errors are 2.3, 1.7, and 1.2, respectively, which is quite encouraging, and, I think, points quite strongly to the reality of the results.

The direction determined by the above quantities is the apex of the nebulas' motion, and the antapex of our motion. It turns out, according to this, that our nebula is moving with a velocity of 670 km /sec in the direction of R. A. 20 hrs. Dec. —20°. This is a point between Sagittarius and Capricorn, about 60 degrees from Pickering's pole of the Galaxy, and while that does not come as near being in the plane of the Galaxy as might be desired, yet it comes as close as could reasonably be expected from a first trial. One wonders whether there is not something in Slipher's conjecture that the spiral nebulae move edgewise.

I think the determination of radial velocities of spiral nebulae should be vigorously pursued, in order to quickly find out whether the above results are indeed real.

University of Iowa.
Dec. 30, 1915.

THE STARRY SICKLE.

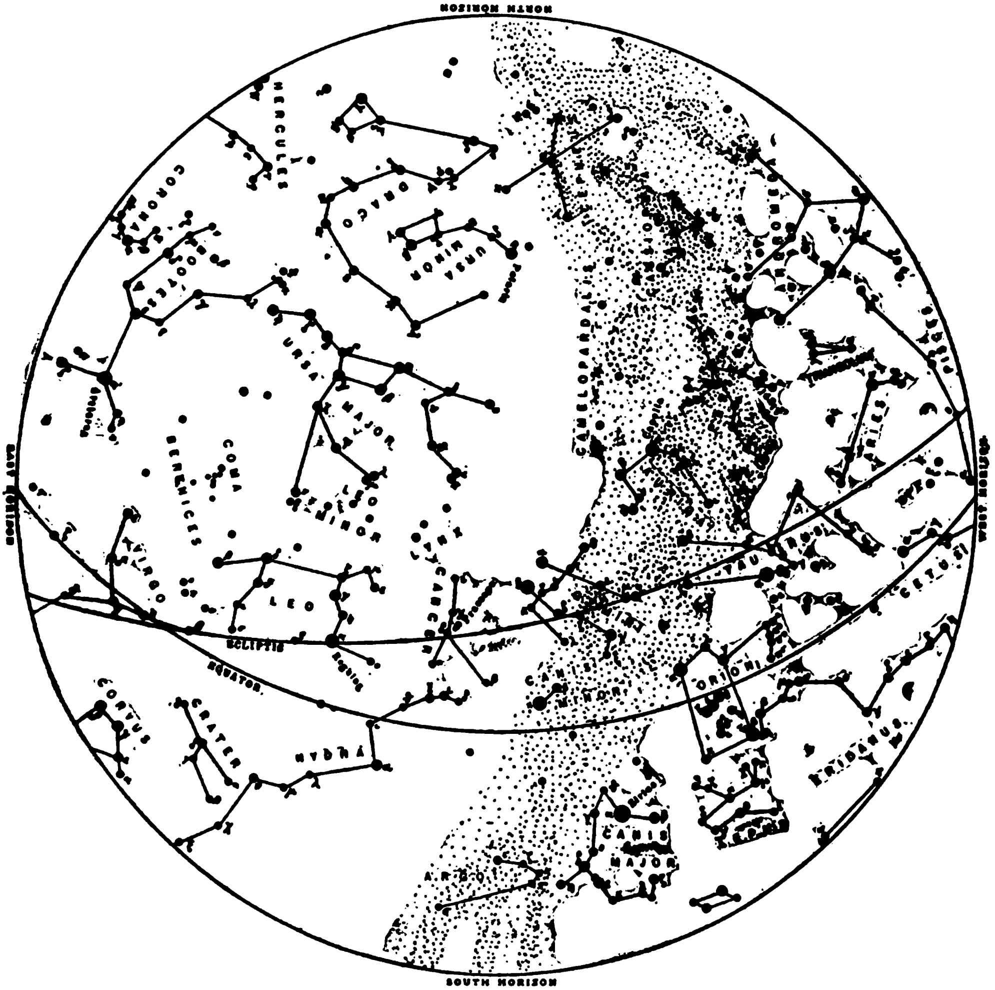
Where Leo waits King Sol in dog-days' reign
And Regulus shines diamond-like and bright,
When springtime wakes and summer smiles again
Till harvest moon beams mellow in the night;
Six suns, with four stars sparkling in its train,
Like question-mark which faces to the right.
Or secret symbol written clear and plain,
A starry sickle glttters in men's sight.

CHARLES NEVERS HOLMES.

Hotel Nottingham, Boston.

PLANET NOTES FOR MARCH, 1916.

The sun will move from 7° 36′ south of the equator to 4° 8′ north of the equator during the month of March. It will cross the equator on March 20. At the time of crossing the equator the right ascension of the sun will be $0^h\ 0^m\ 0^s$, as this is the point from which right ascension is measured. This is the date of the vernal equinox, the date of the beginning of spring.



The Constellations at 9:00 p. m. March 1.

The phases of the moon for this month are as follows:

New Moon	Mar. 3	at	10	P.M.	C.S.T.
First Quarter	11	"	1	P.M.	"
Full Moon	19	"	11	A.M.	"
Last Quarter	26	"	10	A.M.	"

The moon will be at its farthest point from the earth for the month on March 12, and nearest on March 26.

Mercury will be at a point of greatest elongation west of the sun on the first day of the month. It will then be visible in the morning sky. It will be visible during the greater part of the month but will gradually be approaching the sun.

Venus will continue to be the brilliant and conspicuous object in the evening sky throughout the month. It will be a few degrees north and two and a half hours east of the sun. It will be approaching the earth throughout the month. Its average distance from the earth for the month will be about the mean distance from the earth to the sun.

Mars, having just passed a point of opposition, will be favorably situated during this month. It will cross the meridian about nine o'clock in the evening. It will however again be receding from the earth.

Jupiter will scarcely be within reach of observation at all during March. It will be found low in the twilight at sunset at the beginning of the month, and about the middle of the month will be lost in the rays of the sun.

Saturn will be moving westward at the beginning of the month but will turn and move eastward on March 12. It will be in quadrature with the sun, 90° east, on March 30. It will therefore be on the meridian about sunset.

Uranus will be visible in the early morning. It will rise a few hours before the sun.

Neptune will be a short distance northeast of Saturn. It will also therefore be favorably situated for observation. It will have retrograde motion during this month.

Occultations Visible at Washington.

Date 1916	Star's Name	Magnitude	IMMERSION.			EMERSION.			Duration	
			Washington M.T.		Angle f'm N.	Washington M.T.		Angle f'm N.		
			h	m	°	h	m	°	h	m
Mar. 7	47 B Arietis	6.5	8	5	103	9	0	328	0	55
11	112 B Aurigae	5.7	7	24	28	7	57	346	0	33
16	18 Leonis	5.8	4	54	83	5	53	324	0	59
16	19 Leonis	6.4	5	33	112	6	45	299	1	12
16	*R* Leonis(var.)	5-10	5	48	138	6	55	273	1	7
18	359 B Leonis	6.3	7	9	60	7	40	5	0	31
23	π Scorpii	3.0	12	9	162	12	50	240	0	42
23	65 B Scorpii	5.5	16	54	64	18	1	312	1	7
24	95 G Ophiuchi	6.1	17	33	101	18	33	258	1	20
25	66 B Sagittarii	4.7	18	5	73	19	26	266	1	21
26	ψ Sagittarii	4.9	15	36	154	15	59	191	0	23

Saturn's Satellites for March, 1916.

CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.

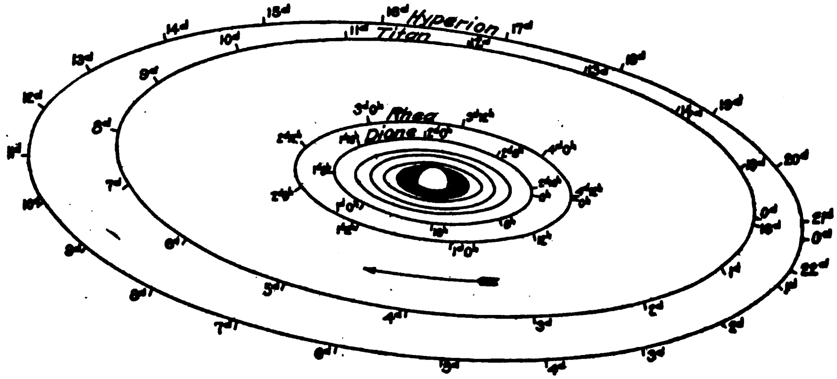
I. Mimas. Period $0^d\ 22^h.6$.

	d	h		h	d		d	h		d	h
Mar.	2	19.9 W	Mar.	8	11.6 W	Mar.	15	13.3 E	Mar.	23	13.5 W
	3	18.6 W		10	20.2 E		16	11.9 E		24	12.2 W
	4	17.2 W		11	18.8 E		19	19.1 W		27	19.4 E
	5	15.8 W		12	17.4 E		20	17.7 W		28	18.0 E
	6	14.4 W		13	16.0 E		21	16.3 W		29	16.6 E
	7	13.0 W		14	14.7 E		22	14.9 W		30	15.3 E
										31	13.9 E

Saturn's Satellites for March, 1916—Continued.

II. Enceladus. Period $1^d\ 8^h.9$.

	d	h		h	h		d	h		d	h
Mar.	1	7.1 E	Mar.	9	12.4 E	Mar.	17	17.7 E	Mar.	25	23.1 E
	2	16.0 E		10	21.3 E		19	2.6 E		27	8.0 E
	4	0.8 E		12	6.2 E		20	11.5 E		28	16.9 E
	5	9.7 E		13	15.1 E		21	20.4 E		30	1.8 E
	6	18.6 E		14	23.9 E		23	5.3 E		31	10.6 E
	8	3.5 E		16	8.8 E		24	14.2 E			



Apparent Orbits of the Seven Inner Satellites of Saturn, at date of Opposition, January 4, 1916, as seen in an Inverting Telescope.

III. Tethys. Period $1^d\ 21^h.3$.

Mar.	1	5.1 E	Mar.	8	18.3 E	Mar.	16	7.6 E	Mar.	23	20.8 E
	3	2.4 E		10	15.6 E		18	4.9 E		25	18.1 E
	4	23.7 E		12	12.9 E		20	2.2 E		27	15.5 E
	6	21.0 E		14	10.3 E		21	23.5 E		29	12.8 E
										31	10.1 E

IV. Dione. Period $2^d\ 17^h.7$.

Mar.	3	6.7 E	Mar.	11	11.8 E	Mar.	19	16.8 E	Mar.	27	21.9 E
	6	0.4 E		14	5.4 E		22	10.5 E		30	15.6 E
	8	18.1 E		16	23.1 E		25	4.2 E			

V. Rhea. $4^d\ 12^h.5$.

Mar.	2	12.6 E	Mar.	11	13.4 E	Mar.	20	14.2 E	Mar.	29	15.2 E
	7	1.0 E		16	1.8 E		25	2.6 E			

VI. Titan. Period $15^d\ 23^h.3$.

Mar.	1	2.9 W	Mar.	9	9.1 E	Mar.	17	1.6 W	Mar.	25	8.0 E

VII. Hyperion. Period $21^d\ 7^h.6$.

Mar.	2	15.4 W	Mar.	12	7.7 E	Mar.	24	1.0 W

VIII. Japetus. Period $79^d\ 22^h.1$.

Mar. 15 5.4 I

IV. Phoebe. Period $523^d\ 15^h.6$.

		α Ph. — α Sat.		δ Ph. — δ Sat.			α Ph. — α Sat.		δ Ph. — δ Sat.	
		m	s	′	″		m	s	′	″
Mar.	1	−0	33.2	+3	2	Mar. 17	−0	54.2	+2	49
	3	0	35.9	3	0	19	0	56.7	2	47
	5	0	38.6	2	58	21	0	59.2	2	46
	7	0	41.2	2	57	23	1	1.7	2	44
	9	0	43.8	2	55	25	1	4.2	2	43
	11	0	46.4	2	54	27	1	6.6	2	42
	13	0	49.0	2	52	29	1	9.0	2	40
	15	−0	51.6	+2	50	31	−1	11.4	+2	39

VARIABLE STARS.

Approximate Magnitudes of Variable Stars of Long Period on Jan. 1, 1916.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.		Decl. 1900.		Magn.	Name.	R.A. 1900		Decl. 1900		Magn.
	h	m	°	′			h	m	°	′	
X Androm.	0	10.8	+46	27	<14.0	T Leporis	5	0.6	−22	2	8.4
T Androm.		17.2	+26	26	11.3*d*	V Orionis		0.8	+ 3	58	10.0 *i*
T Cassiop.		17.8	+55	14	8.8 *i*	R Aurigae		9.2	+53	28	13.8
R Androm.		18.8	+38	1	14.0*d*	W Aurigae		20.1	+36	49	13.0
S Ceti		19.0	− 9	53	9.5*d*	S Aurigae		20.5	+34	4	9.2
Y Cephei		31.3	+79	48	9.2	S Orionis		24.1	− 4	46	8.8*d*
U Cassiop.		40.8	+47	43	11.6*d*	S Camelop.		30.2	+68	45	9.2*d*
RW Androm.		41.9	+32	8	14.0	T Orionis		30.9	− 5	32	9.8
V Androm.		44.6	+35	6	9.2	U Aurigae		35.6	+31	59	13.2*d*
RR Androm.		45.9	+33	50	12.5*d*	SU Tauri		43.2	+19	2	10.2
RV Cassiop		47.1	+46	53	11.5*d*	Z Tauri		46.7	+15	46	<13.0
W Cassiop.		49.0	+58	1	12.3	RU Tauri		46.9	+15	57	<13.0
Z Ceti	1	1.6	− 2	1	13.0	V Camelop.		49.4	+74	30	8.3
U Androm.		9.8	+40	11	10.0 *i*	U Orionis		49.9	+20	10	11.8*d*
S Cassiop.		12.3	+72	5	14.0*d*	Z Aurigae		53.6	+53	18	10.5*d*
S Piscium		12.4	+ 8	24	9.5 *i*	X Aurigae	6	4.4	+50	15	8.7
U Piscium		17.7	+12	21	10.8 *i*	SS Aurigae		5.8	+47	46	<14.0
RZ Persei		23.6	+50	20	13.2*d*	V Aurigae		16.5	+47	45	9.5
R Piscium		25.5	+ 2	22	9.9*d*	V Monoc.		17.7	− 2	9	7.0
RU Androm.		32.8	+38	10	12.5*d*	U Lyncis		31.8	+59	57	14.0
Y Androm.		33.7	+38	50	13.0*d*	S Lyncis		35.9	+58	0	9.1 *i*
X Cassiop.		49.8	+58	46	12.0	Y Monoc.		51.3	+11	22	9.0 *i*
U Persei		53.0	+54	20	8.2 *i*	X Monoc.		52.4	− 8	56	9.0*d*
S Arietis		59.3	+12	3	13.0 *i*	R Lyncis		53.0	+55	28	8.8 *i*
R Arietis	2	10.4	+24	35	12.4	R Geminorum	7	1.3	+22	52	9.1*d*
W Androm.		11.2	+43	50	14.0	V Can. Min.		1.5	+ 9	2	10.2*d*
Z Cephei		12.8	+81	13	<13.5	R Can. Min.		3.2	+10	11	10.2*d*
o Ceti		14.3	− 3	26	3.1	RR Monoc.		12.4	+ 1	17	<13.0
S Persei		15.7	+58	8	8.8 *i*	S Can. Min.		27.3	+ 8	32	7.3 *i*
R Ceti		20.9	− 0	38	8.0 *i*	Z Puppis		28.3	−20	27	13.2
RR Persei		21.7	+50	49	12.2*d*	T Can. Min.		28.4	+11	58	9.2
U Ceti		28.9	−13	35	10.3*d*	U Can. Min.		35.9	+ 8	37	9.5
RR Cephei		29.4	+80	42	13.7	S Geminorum		37.0	+23	41	<13.0
R Trianguli		31.0	+33	50	9.0 *i*	T Geminorum		43.3	+23	59	9.8*d*
W Persei		43.2	+56	34	10.7*d*	U Puppis		56.1	−12	34	14.0
U Arietis	3	5.5	+14	25	13.0 *i*	R Cancri	8	11.0	+12	2	10.4 *i*
X Ceti		14.3	− 1	26	9.3*d*	V Cancri		16.0	+17	36	9.0 *i*
Y Persei		20.9	+43	50	10.0*d*	RT Hydrae		24.7	− 5	59	9.0*d*
R Persei		23.7	+35	20	12.8*d*	U Cancri		30.0	+19	14	12.0*d*
Nov. Per. No. 2		24.4	+43	34	13.5*d*	S Hydrae		48.4	+ 3	27	7.8 *i*
W Tauri	4	22.2	+15	49	9.8 *i*	T Hydrae		50.8	− 8	46	8.4
R Tauri		22.8	+ 9	56	14.0*d*	T Cancri		51.0	+20	14	8.8
S Tauri		23.7	+ 9	44	14.0	S Pyxidis	9	0.7	−24	41	9.5 *i*
T Camelop.		30.4	+65	57	13.8	W Cancri		4.0	+25	39	14.0
X Camelop.		32.6	+74	56	9.0	X Hydrae		30.7	−14	15	11.0
RX Tauri		32.8	+ 8	9	12.3*d*	Y Draconis		31.1	+78	18	<13.5
V Tauri		46.2	+17	22	9.8 *i*	R Leo. Min.		39.6	+34	58	7.7 *i*
R Orionis		53.6	+ 7	59	13.3	RR Hydrae		40.4	−23	34	13.8
R Leporis		55.0	−14	57	7.5	R Leonis		42.2	+11	54	6.8*d*

Approximate Magnitudes of Variable Stars of Long Period on Jan. 1, 1916—Continued.

Name.	R. A. 1900.		Decl. 1900		Magn.	Name.	R. A. 1900.		Decl. 1900		Magn.
	h	m	°	′			h	m	°	′	
Y Hydrae	9	46.4	−22	33	6.8	R Aquilae	19	1.6	+ 8	5	9.5*d*
V Leonis		54.5	+21	44	9.0	V Lyrae		5.2	+29	30	<14.0
R Urs. Maj.	10	37.6	+69	18	7.0	RU Lyrae		9.1	+41	8	12.7*d*
V Hydrae		46.8	−20	43	7.4	S Lyrae		9.1	+25	50	<14.0
W Leonis		48.4	+14	15	11.0*d*	RS Lyrae		9.3	+33	15	<14.5
S Leonis	11	5.7	+ 6	0	10.6 *l*	U Draconis		9.9	+67	7	10.5 *l*
R Com. Ber.		59.1	+19	20	14.2*d*	TZ Cygni		13.4	+50	0	10.8*d*
SU Virginis	12	0.0	+12	56	12.4	U Lyrae		16.6	+37	42	11.8 *l*
T Virginis		9.5	− 5	29	13.8	TY Cygni		29.8	+28	6	11.4 *l*
R Corvi		14.4	−18	42	11.8 *l*	RT Aquilae		33.3	+11	30	13.8
SS Virginis		20.1	+ 1	19	7.0	R Cygni		34.1	+49	58	12.0*d*
T Can. Ven.		25.2	+32	3	12.0	RV Aquilae		35.9	+ 9	42	13.0*d*
Y Virginis		28.7	− 3	52	10.8 *l*	RT Cygni		40.8	+48	32	10.7*d*
T Urs. Maj.		31.8	+60	2	10.8*d*	TU Cygni		43.3	+48	49	10.8*d*
R Virginis		33.4	+ 7	32	7.8 *l*	X Aquilae		46.5	+ 4	13	<13.0
RS Urs. Maj.		34.4	+59	2	8.0 *l*	χ Cygni		46.7	+32	40	6.8 *l*
S Urs. Maj.		39.6	+61	38	8.6	Z Cygni		58.6	+49	46	8.7 *l*
RU Virginis		42.2	+ 4	42	12.5*d*	S Cygni	20	3.4	+57	42	10.3 *l*
U Virginis		46.0	+ 6	6	12.8*d*	S Aquilae		7.0	+15	19	8.2
V Virginis	13	22.6	− 2	39	<13.0	RU Aquilae		8.0	+12	42	11.5*d*
S Virginis		27.8	− 6	41	8.0 *l*	RS Cygni		9.8	+38	28	7.4
T Urs. Min.		32.6	+73	56	12.2*d*	R Delphini		10.1	+ 8	47	13.4*d*
R Can. Ven.		44.6	+40	2	7.8 *l*	SX Cygni		11.6	+30	46	<14.0
U Urs. Min.	14	15.1	+67	15	8.2	U Cygni		16.5	+47	35	7.0
S Bootis		19.5	+54	16	11.5*d*	Z Delphini		28.1	+17	7	14.0*d*
R Camelop.		25.1	+84	17	12.2*d*	ST Cygni		29.9	+54	38	12.8*d*
V Bootis		25.7	+39	18	7.4 *l*	Y Delphini		36.9	+11	31	13.6*d*
S Urs. Min.	15	33.4	+78	58	12.0	V Cygni		38.1	+47	47	9.4*d*
R Cor.Bor.		44.4	+28	28	6.3	S Delphini		38.5	+16	44	10.0 *l*
X Cor. Bor.		45.2	+36	35	10.0*d*	Y Aquarii		39.2	− 5	12	<13.0
V Cor. Bor.		46.0	+39	52	8.5	T Delphini		40.7	+16	2	13.6*d*
R Herculis	16	1.7	+18	38	10.0 *l*	W Aquarii		41.2	− 4	27	9.0 *l*
W Cor. Bor.		11.8	+38	3	8.0	V Delphini		43.2	+18	58	11.4*d*
U Herculis		21.4	+19	7	12.0	T Aquarii		44.7	− 5	31	12.8*d*
SS Herculis		28.0	+ 7	3	9.2	RZ Cygni		48.5	+46	59	11.7*d*
R Urs. Min.		31.3	+72	28	9.4	X Delphini		50.3	+17	16	13.4*d*
R Draconis		32.4	+66	58	12.0*d*	R Vulpeculae		59.9	+23	26	8.4
RV Herculis		56.8	+31	22	<14.0	TW Cygni	21	1.8	+29	0	<13.5
RT Herculis	17	6.8	+27	11	13.8*d*	X Cephei		3.6	+82	40	11.5*d*
RS Herculis		17.5	+23	1	10.2*d*	RS Aquarii		5.8	− 4	27	11.7 *l*
T Draconis		54.8	+58	14	10.4	T Cephei		8.2	+68	5	6.4
V Draconis		56.3	+54	53	9.8	R Equulei		8.4	+12	23	12.2*d*
T Herculis	18	5.3	+31	0	8.5 *l*	RR Aquarii		9.8	− 3	19	<13.0
W Draconis		5.4	+65	56	9.3	X Pegasi		16.3	+14	2	14.0
X Draconis		6.8	+66	8	10.5 *l*	S Cephei		36.5	+78	10	9.6 *l*
W Lyrae		11.5	+36	38	9.3 *l*	RU Cygni		37.3	+53	52	8.5
SV Herculis		22.3	+24	58	11.3*d*	SS Cygni		38.8	+43	8	10.4*d*
T Serpentis		23.9	+ 6	14	<13.5	RR Pegasi		40.0	+24	33	<14.0
SV Draconis		31.2	+49	18	13.6	V Pegasi		56.0	+ 5	38	12.8
RZ Herculis		32.7	+25	58	12.2*d*	RT Pegasi		59.8	+34	38	12.6*d*
RY Lyrae		41.2	+34	34	11.3 *l*	T Pegasi	22	4.0	+12	3	<13.5
RW Lyrae		42.1	+43	32	12.4*d*	Y Pegasi		6.8	+13	52	13.8 *l*
RX Lyrae		50.4	+32	42	13.8	RS Pegasi		7.4	+14	4	9.0
Z Lyrae		56.0	+34	49	13.8	RV Pegasi		21.0	+29	58	<13.0
RT Lyrae		57.8	+37	22	13.4	S Lacertae		24.6	+39	48	12.2*d*

Approximate Magnitudes of Variable Stars of Long Period on Jan. 1, 1916—Continued.

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900.	Decl. 1900.	Magn.
	h m	° ′			h m	° ′	
R Lacertae	22 38.8	+41 51	10.1*d*	R Aquarii	23 38.6	−15 50	9.4*d*
S Aquarii	51.8	−20 53	9.8*d*	Z Cassiop.	39.7	+56 2	14.0
RW Pegasi	59.2	+14 46	9.0 *i*	RR Cassiop.	50.7	+53 8	11.6 *i*
R Pegasi	23 1.6	+10 0	7.3	V Ceti	52.8	− 9 31	9.8 *i*
V Cassiop.	7.4	+59 8	10.7*d*	R Cassiop.	53.3	+50 50	7.8*d*
W Pegasi	14.8	+25 44	12.0	Z Pegasi	55.0	+25 21	8.7 *i*
S Pegasi	15.5	+ 8 22	13.8*d*	Y Cassiop	58.2	+55 7	14.0
Z Androm.	28.8	+48 16	10.8	SV Androm.	59.2	+39 33	13.0
ST Androm.	33.8	+35 13	11.2*d*				

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—T. C. H. Bouton, A. B. Burbeck, L. Campbell, H. O. Eaton, G. L. Harrell, W. P. Hoge, S. C. Hunter, J. B. Lacchini, C. B. Lindsley, O. Mach, C. Y. McAteer, C. S. Mundt, G. F. Nolte, W. T. Olcott, D. B. Pickering, C. F. Richter, H. M. Swartz, H. W. Vrooman, I. E. Woods, and A. S. Young

Maxima of Variable Stars of Short Period.

[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1916. March
	h m	° ′		d h	d h d h d h d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7	24 3
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	8 12; 16 15; 24 18; 28 20
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	7 5; 14 22; 22 16; 30 10
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	2 7; 17 2; 31 22
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	2 0; 9 22; 17 21; 25 19
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	1 3; 8 22; 16 17; 24 13
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	1 3; 8 10; 15 16; 22 23
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	6 0; 19 0
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	2 19; 11 9; 19 23; 28 13
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	1 13; 12 16; 23 19
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	8 11; 20 2; 31 17
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	1 7; 8 23; 16 15; 24 7
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	2 4; 12 8; 22 11
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	8 7; 16 0; 23 17; 31 11
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	4 20; 10 9; 15 21; 21 10
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	7 12; 15 1; 22 15; 30 5
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	1 17; 28 18
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	7 12; 14 17; 21 22; 29 3
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	6 1; 13 23; 21 21; 29 19
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 10; 13 14; 23 17
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	15 6
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	8 5; 16 4; 24 2; 28 1

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. March							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
V Carinae	8	26.7	−59	47	7.4— 8.1	6	16.7	2	4;	8	21;	15	13;	22	6
T Velorum	8	34.4	−47	01	7.6— 8.5	4	15.3	10	3;	19	10;	24	1;	28	16
V Velorum	9	19.2	−55	32	7.5— 8.2	4	08.9	8	2;	16	20;	21	5;	25	14
Z Leonis	9	46.4	+27	22	7.9— 9.6	59	0.0							29	0
RR Leonis	10	02.1	+24	29	9.1—10.1	0	10.9	2	1;	8	20;	15	15;	22	9
SU Draconis	11	32.2	+67	53	8.9— 9.6	0	15.8	2	12;	9	2;	15	17;	22	17
S Muscae	12	07.4	−69	36	6.4— 7.3	9	15.8	6	15;	16	6;	25	22		
SW Draconis		12.8	+70	04	8.8— 9.6	0	13.7	2	20;	10	19;	18	18;	26	18
T Crucis		15.9	−61	44	6.8— 7.6	6	17.6	2	17;	9	11;	16	5;	22	22
R Crucis		18.1	−61	04	6.8— 7.9	5	19.8	4	23;	10	19;	16	15;	22	11
S Crucis	12	48.4	−57	53	6.5— 7.6	4	16.6	3	19;	8	12;	17	21;	27	6
W Virginis	13	20.9	− 2	52	8.7—10.4	17	06.5	6	7;	23	13				
SS Hydrae		25.0	−23	08	7.4— 8.1	8	4.8	6	10;	14	14;	22	19;	31	0
RV Urs. Maj.	13	29.4	+54	31	9.2— 9.9	0	11.2	6	13;	13	14;	20	14;	27	15
ST Virginis	14	22.5	− 0	27	10.3—11.4	0	09.9	3	16;	11	21;	20	3;	28	8
V Centauri		25.4	−56	27	6.4— 7.8	5	11.9	3	0;	8	12;	19	12;	30	12
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	6	16;	14	6;	21	19;	29	8
RU Bootis	14	41.5	+23	44	12.8—14.3	0	11.9	4	8;	11	18;	19	4;	26	14
R Triang. Austr.	15	10.8	−66	08	6.7— 7.4	3	09.3	2	21;	9	15;	16	10;	23	5
S Triang. Austr.	15	52.2	−63	29	6.4— 7.4	6	07.8	6	4;	12	12;	18	20;	25	4
S Normae	16	10.6	−57	39	6.6— 7.6	9	18.1	6	17;	16	11;	26	5		
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	1	5;	10	2;	18	22;	27	19
RV Scorpii	16	51.8	−33	27	6.7— 7.4	6	01.5	1	13;	7	15;	13	16;	25	19
X Sagittarii	17	41.3	−27	48	4.4— 5.0	7	00.3	7	22;	14	22;	21	22;	28	22
Y Ophiuchi		47.3	− 6	07	6.1— 6.5	17	02.9			12	13;	29	16		
W Sagittarii	17	58.6	−29	35	4.3— 5.1	7	14.3	1	14;	9	5;	16	19;	24	9
Y Sagittarii	18	15.5	−18	54	5.4— 6.2	5	18.6	2	4;	7	23;	13	17;	25	6
U Sagittarii		26.0	−19	12	6.5— 7.3	6	17.9	1	9;	8	3;	14	21;	21	15
Y Scuti		32.6	− 8	27	8.7— 9.2	10	08.3	9	1;	18	9;	29	17		
Y Lyrae		34.2	+43	52	11.3—12.3	0	12.1	6	23;	12	23;	19	0;	25	1
RZ Lyrae		39.9	+32	42	9.9—11.2	0	12.3	5	21;	12	1;	18	4;	24	7
RT Scuti		44.1	−10	30	9.1— 9.7	0	11.9	5	22;	11	21;	17	20;	23	19
κ Pavonis	18	46.6	—67	22	3.8— 5.2	9	02.2	6	19;	15	22;	25	0		
U Aquilae	19	24.0	− 7	15	6.2— 6.9	7	00.6	7	22;	14	23;	22	23;	30	0
XZ Cygni		30.4	+56	10	8.6— 9.3	0	11.2	1	6;	8	6;	15	6;	29	6
U Vulpec.		32.2	+20	07	6.5— 7.6	7	23.5	4	10;	12	10;	20	9;	28	9
SU Cygni		40.8	+29	01	6.2— 7.0	3	20.3	1	23;	9	16;	17	8;	25	1
η Aquilae		47.4	+ 0	45	3.7— 4.5	7	04.2	4	3;	11	8;	18	12;	25	16
S Sagittae		51.5	+16	22	5.6— 6.4	8	09.2	6	12;	14	22;	23	6;	31	15
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	3	21:	10	5;	16	13;	22	20
X Cygni	20	39.5	+35	14	6.0— 7.0	16	09.3			16	12				
T Vulpec.		47.2	+27	52	5.5— 6.1	4	10.5	1	14;	6	0;	14	21;	28	4
WY Cygni		52.3	+30	03	9.6—10.4	0	13.5	3	14;	10	7;	17	1;	23	18
RV Capric.		55.9	−15	37	9.2—10.1	0	10.7	2	22;	9	15;	16	8;	29	18
TX Cygni	20	56.4	+42	12	8.5— 9.7	14	17.4	6	0;	20	17				
VY Cygni	21	00.4	+39	34	8.8— 9.5	7	20.6	6	8;	14	4;	22	1;	29	21
SW Aquarii		10.2	— 0	20	9.9—10.8	0	11.0	3	12;	10	9;	17	7;	24	4
VZ Cygni	21	47.7	+42	40	8.2— 9.2	4	20.7	5	9;	10	6;	15	3;	24	20
Y Lacertae	22	05.2	+50	33	9.1— 9.6	4	07.8	6	0;	14	16;	23	8;	31	23
δ Cephei		25.5	+57	54	3.7— 4.6	5	08.8	3	16;	9	1;	14	10;	25	4
Z Lacertae		36.9	+56	18	8.2— 9.0	10	21.1			11	8;	22	5		
RR Lacertae		37.5	+55	55	8.5— 9.2	6	10.1	1	10;	7	20;	14	6;	20	16
V Lacertae	22	44.5	+55	48	8.5— 9.5	4	23.6	3	23;	8	23;	13	22;	23	21
SW Cassiop.	23	03.7	+58	11	9.2— 9.7	5	10.6	3	8;	8	18;	19	15;	30	12
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	5	1;	11	8;	17	16;	23	23
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4	1	14;	13	18;	25	21		
V Cephei	23	51.7	+82	38	6.0—7.0	0	23.6	3	14;	8	14;	18	13;	28	13

Minima of Variable Stars of Short Period.

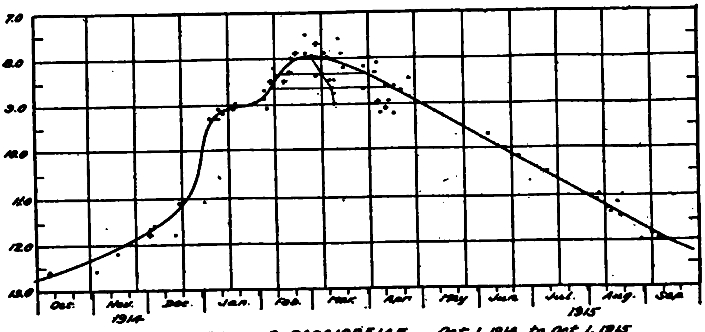
[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5ʰ; Central Standard 6ʰ; etc.

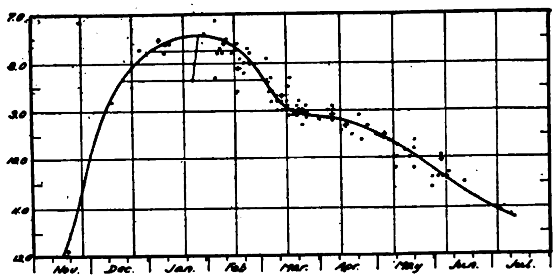
Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 March							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.8			15	4				
RT Sculptor.		31.5	—26	13	9.6—10.5	0	12.3	3	13;	11	5;	18	21;	26	13
UU Androm.		38.5	+30	24	10.7—11.9	1	11.7	4	4;	11	14;	19	1;	26	11
U Cephei	0	53.4	+81	20	7.0— 9.0	2	11.8	7	14;	15	1;	22	13;	30	10
Z Persei	2	33.7	+41	46	9.4—12	3	01.4	7	14;	13	17;	19	20;	25	22
TW Cassiop.		37.6	+65	19	8.2— 9.0	1	10.3	3	7;	10	10;	24	17;	31	21
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	4	20;	11	17;	18	13;	25	10
RZ Cassiop.		39.9	+69	13	6.9— 8.1	1	04.7	7	5;	13	10;	20	14;	27	18
TX Cassiop.		44.4	+62	22	9.4—10.1	2	22.2	8	14;	17	8;	26	3		
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	3	18;	11	17;	19	15;	27	14
RX Cassiop.	2	58.8	+67	11	8.6— 9.1	32	07.6			15	14				
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	5	3;	10	21;	22	8;	28	1
RT Persei		16.7	+46	12	9.5—11.5	0	20.4	4	6;	11	1;	24	15;	31	10
λ Tauri		55.1	+12	12	3.3— 4.2	3	22.9	6	17;	14	14;	22	12;	30	10
RW Tauri	3	57.8	+27	51	7.1—< 11	2	18.5	7	21;	16	5;	24	12		
RV Persei	4	04.2	+33	59	9.5—11.0	1	23.4	3	17;	11	11;	19	12;	27	9
RW Persei		13.3	+42	04	8.8—11.0	15	04.8	5	20;	19	1				
SZ Tauri		31.4	+18	20	7.2— 7.7	3	03.6	5	0;	14	11;	23	21		
RS Cephei	4	48.6	+80	06	9.5—12.0	12	10.1	5	14;	18	0;	30	10		
TT Aurigae	5	02.8	+39	27	7.8— 8.7	0	16.0	2	1;	8	17;	22	1;	28	17
RY Aurigae		11.5	+38	13	10.7—11.7	2	17.5	3	6;	14	3;	25	1;	30	12
RZ Aurigae		42.9	+31	40	10.6—13.3	3	00.3	1	14;	7	14;	19	15;	31	16
SV Tauri		45.8	+28	05	9.4—11.0	2	04.0	5	6;	13	22;	22	14;	31	6
Z Orionis		50.2	+13	40	9.7—10.7	5	04.9			16	17;	27	3		
SV Gemin.		54.6	+24	28	9.8—< 11	4	00.2	7	10;	15	10;	23	11;	31	11
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	1	14;	7	8;	18	19;	30	6
U Columbae	6	11.2	—33	03	9.2—10.0	2	19.2	3	5;	8	19;	20	0;	31	5
SX Gemin.		22.0	+20	37	10.8—11.5	1	08.8	8	7;	16	12;	24	17		
RW Monoc.		29.3	+ 8	54	9.0—10.8	1	21.7	5	14;	13	5;	20	20;	28	11
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0	1	10;	13	15;	25	20		
RU Monoc.	6	49.4	— 7	28	9.8—10.5	0	21.5	4	15;	11	19;	18	23;	26	3
R Can. Maj.	7	14.9	—16	12	5.8— 6.4	1	03.3	5	18;	14	21;	23	23		
RY Gemin.		21.7	+15	52	8.9—<10	9	07.2	3	9;	12	16;	22	0;	31	7
Y Camelop.		27.6	+76	17	9.5—12	3	07.3	5	13;	14	11;	24	9		
TX Gemin.		30.3	+17	8	10.0—11.9	2	19.2	8	24;	17	10;	25	20		
RR Puppis		43.5	—41	08	9.4—10.7	6	10.3	1	17;	8	4;	14	14		
V Puppis	7	55.4	—48	58	4.1— 4.8	1	10.9	3	9;	10	16;	17	22;	25	5
X Carinae	8	29.1	—58	53	7.9— 8.7	0	13.0	1	5;	9	7;	17	10;	25	3
S Cancri	8	38.2	+19	24	8.2—10	9	11.6	4	18;	14	5;	23	17		
RX Hydrae	9	00.8	— 7	52	9.1—10.5	2	6.8	5	10;	14	13;	23	16		
S Antliae		27.9	—28	11	6.7— 7.3	0	07.8	3	22;	10	10;	23	9;	29	21
S Velorum		29.4	—44	46	7.8— 9.3	5	22.4	2	2;	7	23;	19	21;	31	18
Y Leonis	9	31.1	+26	41	9.3—11.2	1	16.5	6	11;	14	21;	23	8;	31	18
RR Velorum	10	17.8	—41	36	10.0—10.9	1	20.5	4	14;	13	21;	23	3		
SS Carinae	10	54.2	—61	23	12.2—12.8	3	07.2	4	1;	10	15;	23	20;	30	11
ST Urs. Maj.	11	22.4	+45	44	6.7— 7.2	8	19.2	7	14;	16	10;	25	5		
RW Urs. Maj.		35.4	+52	34	10.3—11.4	7	07.9	6	9;	13	17;	21	1;	28	9
Z Draconis	11	39.8	+72	49	9.9—13.6	1	08.6	4	0;	10	19;	23	9;	30	4
RZ Centauri	12	55.6	−64	05	8.5— 8.9	1	21.0	6	6;	13	18;	21	7;	28	19
RS Can. Ven.	13	06.3	+36	28	7.5—12.5	4	19.2	7	18;	17	9;	26	23		
SS Centauri	13	07.2	—63	37	8.8—10.4	2	11.5	6	0;	13	10;	20	20;	28	7
δ Librae	14	55.6	— 8	07	4.8— 6.2	2	07.9	2	7;	9	6;	23	5;	30	5

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 March							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
U Coronae	15	14.1	+32	01	7.6— 8.7	3	10.9	2	4;	9	1;	22	21;	29	19
TW Draconis		32.4	+64	14	7.3— 8.9	2	19.4	4	4;	12	14;	21	1;	29	11
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	2	8;	10	0;	17	16;	25	7
SW Ophiuchi	16	11.1	— 6	44	9.2—10.0	2	10.7	7	2;	14	10;	21	18;	29	2
SX Ophiuchi		12.6	— 6	25	10.5—11.2	2	01.5	5	23;	14	5;	22	11;	30	17
R Arae		31.1	—56	48	6.8— 7.9	4	10.2	5	9;	14	6;	23	2;	31	23
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1	1	15;	11	8;	22	9		
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	7	19;	14	14;	21	10;	28	5
U Ophiuchi		11.5	+ 1	19	6.0— 6.7	0	20.1	7	5;	15	14;	23	23		
u Herculis		13.6	+33	12	4.6— 5.4	2	01.2	4	15;	10	19;	23	2;	29	6
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	5	8;	12	13;	19	18;	26	23
RV Ophiuchi		29.8	+ 7	19	9. —12	3	16.5	3	3;	10	12;	17	21;	25	6
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	1	23;	10	3;	18	8;	26	12
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	6	12;	14	1;	21	14;	29	3
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	8	5;	15	23;	23	17;	31	11
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	1	3;	9	3;	17	3;	25	2
WX Sagittae		53.6	—17	24	9.2—10.8	2	03.1	4	5;	12	17;	21	6;	29	18
WY Sagittae	17	54.9	—23	1	9.5—10.6	4	16.0	5	14;	14	22;	24	6		
SX Draconis	18	03.0	+ 58	23	9.3—10.5	5	04.1	4	20;	14	4;	24	12		
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	6	12;	13	18;	20	23;	28	5
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	6	12;	13	9;	20	7;	27	5
RZ Scuti		21.1	— 9	15	7.4— 8.3	15	03.2	2	5;	17	18				
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	7	1;	15	7;	23	14;	31	20
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	1	23;	10	20;	19	17;	28	15
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	7	20;	16	4;	24	11		
RR Draconis		40.8	+62	34	9.3—13	2	19.9	1	22;	10	9;	18	20;	27	7
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	2	1;	8	17;	22	0;	28	15
β Lyrae		46.4	+33	15	3.4— 4.1	12	21.8			11	9;	24	7		
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	9	15;	19	5;	28	18		
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	4	4;	11	18;	19	7;	26	21
RV Lyrae		12.5	+32	15	11. —12.8	3	14.4			11	8;	18	13;	25	18
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	5	17;	14	15;	23	14		
U Sagittae		14.4	+19	26	6.5— 9.0	3	09.1	3	20;	10	14;	24	3;	30	21
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	1	9;	8	18;	23	11;	30	20
TT Lyrae		24.3	+41	30	9.3—11.6	5	05.8	5	16;	10	21;	21	9;	31	20
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	3	4;	9	17;	22	18;	29	6
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	5	10;	11	10;	23	10;	29	10
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	6	9;	13	0;	19	16;	26	7
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	1	22;	11	1;	20	5;	29	8
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	3	7;	11	17;	20	4;	28	14
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	2	21;	9	16;	23	5;	30	0
UW Cygni		19.6	+42	55	10.5—13	3	10.8	6	0;	12	21;	19	20;	26	17
V Vulpec.		32.3	+26	15	8.2—9.8	37	19.0			23	5				
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	9	18;	19	9;	29	0		
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	2	14;	11	19;	21	0		
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	1	4;	8	15;	23	15;	31	3
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	4	7;	10	4;	21	20;	27	16
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2			10	18;	20	21;	30	23
VV Cygni	21	02.3	+45	23	12.1—13.8	1	11.4	3	7;	10	16;	18	1;	25	10
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	5	9;	15	1;	24	7		
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	5	13;	13	10;	21	7;	29	3
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3			17	5				
RT Lacertae	21	57.4	+43	24	9.1—10.5	5	01.7	2	23;	13	3;	23	6		
RW Lacertae	22	40.6	+49	08	10.2—11.2	5	04.4	5	9;	10	13;	20	22;	31	7
X Lacertae	22	45.0	+55	54	8.2— 8.6	5	10.6	5	15;	11	2;	21	23;	27	10
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.3	8	20;	17	3;	25	10		
Y Piscium		29.3	+ 7	22	9.0—12.0	3	18.4	4	12;	12	0;	19	13;	27	2
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	6	8;	14	14;	22	20;	31	2

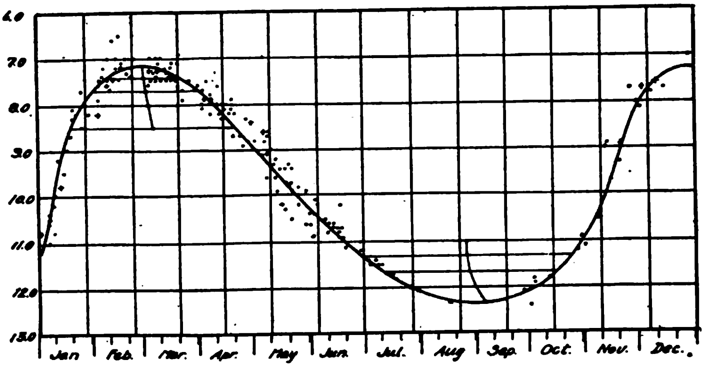


011272 S CASSIOPEIAE Oct. 1, 1914 to Oct. 1, 1915
Maximum Mar. 2, 1915; magnitude 7.9
Observations by Amer. Assn. of Var. Star Observers. Chas. B. Lindsley

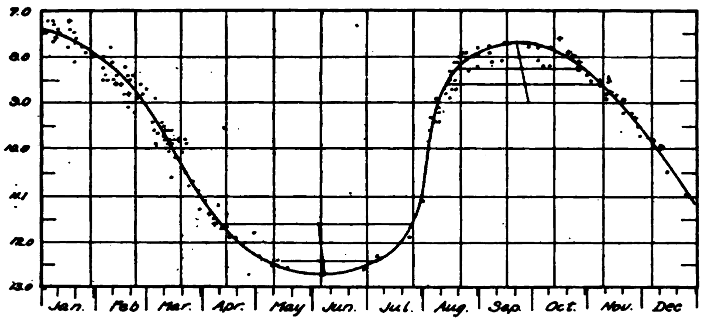


093934 R LEO MINORIS Chas. B. Lindsley

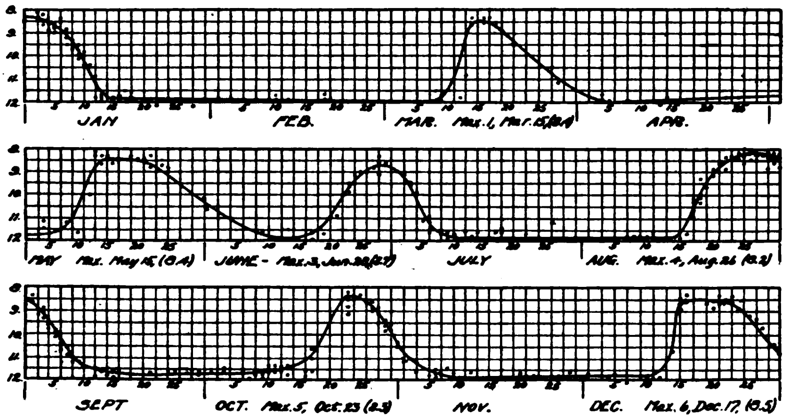
Maximum Jan. 27, 1915; mag. 7.4
Observations by Am. Assn. of Var. Star Observers
(x = obs by C.B.L.)



103769 R URSAE MAJORIS for 1915 C.B. Lindsley
Maximum Mar. 1, mag. 7.1; minimum Sept. 4, mag. 12.3.
Observations by Amer. Assn. of Var. Star Observers. (x=obs. by C.B.L.)



123160 T URSAE MAJORIS FOR 1915 Chas. B. Lindsley
Minimum June 6, (12.7); max. Sept. 21, (7.7)
From Observations by Amer. Assn. of Var. Star Observers.



LIGHT CURVE for 1915 of 213843 SS CYGNI Chas. B. Lindsley.
Observations by American Association of Variable Star Observers.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Dec.-Jan., 1915-16.

The bad weather that seems to have prevailed generally over the United States during the past month is reflected in the small report we publish this month. In addition to this, the social demands of the holiday season have prevented many from observing, and the result is the smallest monthly list for three years.

There have been many inquiries of late concerning the work of the Association, and the prospects are bright for a largely augmented membership during the coming year.

VARIABLE STAR OBSERVATIONS Dec.-Jan., 1915-16.

001726
T Androm.

Mo.	Day	Est.	Obs.
12	2	9.4	V
	2	9.7	Ly
	3	9.7	Bu
	5	9.6	O
	10	9.9	Ly
	11	10.3	Nt
	31	11.3	Nt

001755
T Cassiop.

Mo.	Day	Est.	Obs.
12	3	9.0	Bu
	4	9.2	S
	22	8.7	E
	30	8.8	S
	31	8.8	Nt

001838
R Androm.

Mo.	Day	Est.	Obs.
12	26	11.3	Hu

001909
S Ceti

Mo.	Day	Est.	Obs.
12	3	8.5	Cr
	3	8.5	O
	3	8.4	Bu
	4	8.3	Ma
	7	8.5	O
	9	8.3	Hu
	30	9.0	S

003179
Y Cephei

Mo.	Day	Est.	Obs.
12	3	9.8	Bu

004047
U Cassiop.

Mo.	Day	Est.	Obs.
11	17	8.7	L
12	3	8.9	B
	11	10.5	Nt
	31	11.6	Nt

004435
V Androm.

Mo.	Day	Est.	Obs.
12	3	9.7	Bu
	5	9.5	O
	9	9.2	Hu
	12	9.4	Nt

004533
RR Androm.

Mo.	Day	Est.	Obs.
12	9	11.9	Hu

004746
RV Cassiop.

Mo.	Day	Est.	Obs.
11	17	10.1	L

011208
S Piscium

Mo.	Day	Est.	Obs.
12	5	9.8	O
	14	9.5	Bu
	31	9.9	O

012502
R Piscium

Mo.	Day	Est.	Obs.
12	3	9.2	Bu
	4	9.2	S
	5	9.1	O
	31	10.0	O

015254
U Persei

Mo.	Day	Est.	Obs.
12	2	8.5	V
	3	8.5	Bu
	7	8.5	O
	10	8.6	Ly

021403
o Ceti

Mo.	Day	Est.	Obs.
11	6	6.5	L
	30	3.7	Ma
12	1	3.6	E
	1	3.7	Cr
	2	4.0	Ly
	3	4.0	O
	3	3.6	Bu
	3	3.6	Ma
	3	3.7	Cr
	4	3.4	Cr
	4	3.8	Nt
	5	3.4	E
	5	3.8	O
	6	3.6	Mu
	6	3.3	L
	7	3.6	O
	7	3.3	E
	7	3.8	Nt
	7	3.4	Mu
	9	3.3	Mu
	9	2.9	Hu
	10	3.4	Ly
	10	3.6	O
	11	3.4	O
	11	3.2	L
	11	3.7	Nt
	13	3.2	E
	19	2.8	Bu
	19	3.1	E
	21	3.2	O
	22	3.0	G
	22	3.0	Ma
	22	3.0	E
	22	2.4	M
	22	3.1	Mu
	23	3.2	G
	24	3.0	Mu
	25	3.5	G
	25	3.1	Mu
	26	3.0	Nt
	26	3.2	Pi
	26	3.1	Mu
	27	2.9	E
	27	3.1	Mu
	29	3.2	Mu
	30	3.5	Mu

o Ceti

Mo.	Day	Est.	Obs.
12	30	3.1	Nt
	30	3.5	G
	30	3.2	Cr
	30	3.2	O
	31	3.2	O
	31	3.1	Cr
	31	3.4	Mu
1	1	3.6	G
	6	3.2	O
	7	3.3	O
	9	3.3	O

021658
S Persei

Mo.	Day	Est.	Obs.
12	2	8.8	Ly
	3	8.5	Bu

022000
R Ceti

Mo.	Day	Est.	Obs.
12	31	7.9	O
1	7	7.9	O

022813
U Ceti

Mo.	Day	Est.	Obs.
11	30	9.0	Ma
12	9	9.0	Ma
	26	10.1	Pi
	31	10.3	Nt

023133
R Triang.

Mo.	Day	Est.	Obs.
12	11	9.7	Y

024356
W Persei

Mo.	Day	Est.	Obs.
11	11	10.2	L
12	11	10.3	Hu
	26	10.4	Pi

030514
U Arietis

Mo.	Day	Est.	Obs.
12	31	13.5	B

032043
Y Persei

Mo.	Day	Est.	Obs.
12	3	10.0	Bn
	7	9.9	Ly
	11	10.6	Hu

032335
R Persei

Mo.	Day	Est.	Obs.
12	3	10.0	Bu

033362
U Camelop.

Mo.	Day	Est.	Obs.
11	30	8.5	Ma
12	26	8.4	Pi

035915
V Eridani

Mo.	Day	Est.	Obs.
11	26	8.1	Ho

042036
T Camelop.

Mo.	Day	Est.	Obs.
12	11	13.5±	Y

042209
R Tauri

Mo.	Day	Est.	Obs.
12	1	13.4	B
	11	12.0	Hu

042215
W Tauri

Mo.	Day	Est.	Obs.
12	1	11.9	B
	9	11.4	Hu
	11	11.0	O
	22	10.7	M
	30	10.6	O
	31	9.5	B
1	6	10.1	O
	9	9.8	O

042309
S Tauri

Mo.	Day	Est.	Obs.
12	11	11.6	Hu

043208
RX Tauri

Mo.	Day	Est.	Obs.
12	1	8.7	B
	3	9.0	O
	11	9.3	Hu
	11	9.0	O
	24	9.0	B
	30	9.0	O
1	6	9.1	O

043274
X Camelop.

Mo.	Day	Est.	Obs.
11	6	8.5	L
	30	9.0	B
12	3	9.3	O
	5	9.0	O
	7	9.9	O
	7	9.8	Ly
	10	10.3	O
	11	10.8	L
	26	12.0	Pi
	31	12.3	Nt

044617
V Tauri

Mo.	Day	Est.	Obs.
12	1	10.3	B
	11	10.3	O
	14	9.6	Bu
	24	9.4	B
	30	10.1	O
	31	9.6	Nt

045514
R Leporis

Mo.	Day	Est.	Obs.
11	17	7.1	L
	26	7.1	Ho
12	10	7.4	Bu
	12	7.4	Ho

050003
V Orionis

Mo.	Day	Est.	Obs.
12	15	10.7	B

050022
T Leporis

Mo.	Day	Est.	Obs.
11	26	8.8	Ho
12	10	8.8	Bu
	12	6.3	Ho
	26	8.5	M

050953
R Aurigae

Mo.	Day	Est.	Obs.
11	28	13.0	B
12	27	12.8	B

052034
S Aurigae

Mo.	Day	Est.	Obs.
11	15	9.8	L
	30	8.9	B
12	11	9.8	L
	21	8.7	B
	26	9.2	Pi

052405
S Orionis

Mo.	Day	Est.	Obs.
11	26	7.9	Ho
12	3	8.8	Bu
	12	8.1	Ho
	15	8.4	B
	16	8.5	B
	22	8.4	M
	26	8.7	M

053005
T Orionis

Mo.	Day	Est.	Obs.
11	17	9.8	L
	26	9.8	Ho
12	3	10.0	Bu
	7	9.5	Nt
	10	9.4	B
	12	9.4	Ho
	22	9.3	M
	26	9.4	Pi
	27	9.5	E
	31	9.6	Nt

054319
SU Tauri

Mo.	Day	Est.	Obs.
1	7.5	9.5	O
	9.5	9.7	O

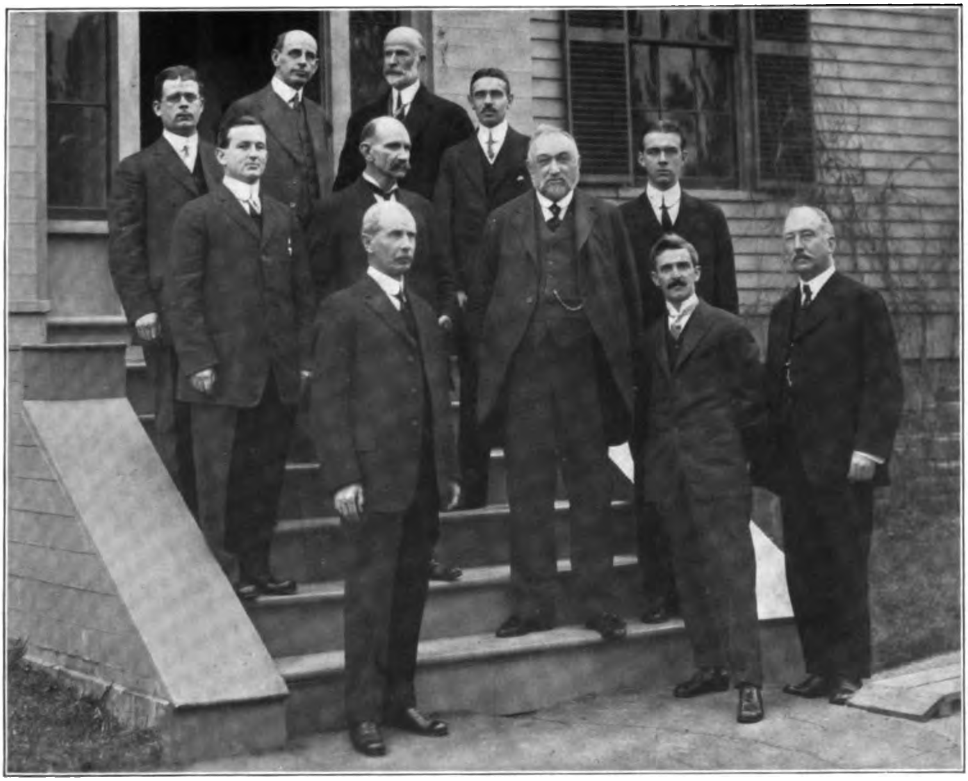
054920
U Orionis

Mo.	Day	Est.	Obs.
12	11	11.0	Hu
	11	12.2	Y
	26	11.6	Pi

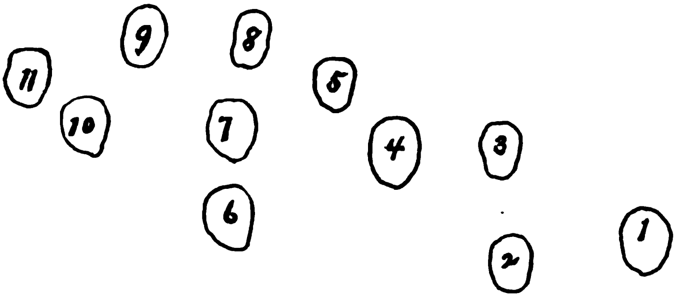
054974
V Camelop.

Mo.	Day	Est.	Obs.
12	3	10.5	O
	5	9.7	O
	10	9.5	O
	11	9.1	Y
	20	8.6	B

PLATE IV



Meeting of the American Association of Variable Star Observers at the Harvard College Observatory, Nov. 21, 1915



Key

1. J. L. Steuart
2. L. Campbell
3. G. F. Nolte
4. Prof. E. C. Pickering
5. W. T. Olcott
6. Rev. T. C. H. Bouton
7. C. Y. McAteer
8. Prof. S. I. Bailey
9. D. B. Pickering
10. F. H. Spinney
11. A. B. Burbeck

VARIABLE STAR OBSERVATIONS Dec.-Jan., 1915-16—Continued.

		Mo.	Day	Est.	Obs.
	V Camelop.	12	21	8.5	B
			26	8.3	Pi
			30	9.0	O
		1	6	9.0	O
			9	9.0	O
055353	Z Aurigae	12	26	10.0	Pi
060224	S Leporis	11	26	6.3	Ho
		12	12	6.2	Ho
060450	X Aurigae	11	1	10.2	L
		12	3	8.6	Bu
			26	8.6	Pi
060547	SS Aurigae	12	1.6	13.6	B
061647	V Aurigae	12	19	9.2	Bu
061702	V Monoc.	11	26	9.0	Ho
		12	12	7.3	Ho
063558	S Lyncis	12	5	9.9	O
			7	9.6	Bu
			11	9.9	Y
			11	9.6	O
			20	9.5	B
			30	9.8	O
		1	6	9.8	O
			9	9.4	O
065111	Y Monoc.	12	7	10.4	Bu
065208	X Monoc.	11	17	10.2	L
			26	7.5	Ho
		12	7	7.6	Bu
			12	8.0	Ho
065358	R Lyncis	12	11	9.7	Y
			27	8.9	B
		1	9	8.9	O
070122	R Gemin.	12	31	9.1	Nt
070122 a	TW Gemin.	12	26	8.4	M
			31	7.9	Nt
070122 b	Z Gemin.	12	31	12.3	Nt
070310	R Can. Min.	11	17	10.2	L
072708	S Can. Min.	11	17	8.6	L
		12	7	7.9	Ly
			26	7.3	M
073508	U Can. Min.	11	17	9.7	L
074323	T Gemin.	12	26	9.7	M
081112	R Cancri	11	17	11.0	L
082405	RT Hydrae	11	17	8.9	L
		12	12	8.5	Ho
094211	R Leonis	11	17	5.8	L
		12	14	6.6	M
			27	6.5	E
094622	Y Hydrae	12	12	6.5	Ho
103212	U Hydrae	11	17	5.0	L
103769	R Urs. Maj.	12	2	7.7	Ly
			4	7.5	S
			7	7.8	Bu
			10	7.6	Ly
			14	7.7	M
			29	7.0	M
104620	V Hydrae	11	17	6.4	L
			26	6.6	Ho
		12	12	6.7	Ho
122904	Y Virginis	12	12	11.4	Ho
123160	T Urs. Maj.	12	7	10.0	Bu
			7	9.8	Ly
			12	10.0	Ly
			14	10.5	M
			27	11.0	E
123307	R Virginis	11	17	10.6	L
123459	RS Urs. Maj.	12	14	9.3	M
123961	S Urs. Maj.	12	4	8.8	S
			7	8.2	Bu
			7	8.5	Ly
			14	8.7	M
			22	8.5	E
			27	8.4	E
			30	8.4	S
134440	R Can. Ven.	12	14	7.8	M
141567	U Urs. Min.	12	4	8.2	S
			7	8.3	Bu
			7	7.9	Ly
			20	7.7	B
141954	S Bootis	12	12	11.3	Nt
142539	V Bootis	11	11	7.4	L
142584	R Camelop.	11	11	10.3	L
		12	11	11.8	L
			12	11.4	Ly
			31	12.5	B
143227	R Bootis	11	11	6.7	L
153378	S Urs. Min.	11	6	11.7	L
		12	7	12.0	Ly
			12	12.0	Ly
154428	R Cor. Bor.	10	22.2	6.1	L
		11	1.2	6.0	L
			11.2	6.3	L
			17.2	6.5	L
			23.2	6.6	L
		12	30.9	6.3	Nt
155847	X Herculis	12	12	6.8	Nt
			26	6.5	Nt
162807	SS Herculis	11	11	9.9	L
163172	R Urs. Min.	11	28	10.1	R
		12	2	9.9	Ly
			20	9.8	Hr
			27	10.0	E
163266	R Draconis	12	1	11.7	Cr
			3	11.8	Cr
			4	11.7	Cr
			7	11.9	Ly
			31	11.8	B
164055	S Draconis	11	28	8.6	R
171723	RS Herculis	11	28	9.9	R
175458	T Draconis	12	20	9.6	Hr
181136	W Lyrae	12	22	9.9	M
183308	X Ophiuchi	11	11	7.0	L
			28	8.8	R
184205	R Scuti	10	22.2	6.1	L
		11	11.2	5.3	L
			17.2	5.2	L
			23.2	4.9	L
	R Scuti	11	28.6	5.0	R
			29.6	5.5	R
		12	4.5	5.2	Ma
			7.5	5.0	Ly
			11.5	5.7	Nt
184243	RW Lyrae	12	27	12.6	E
185243	R Lyrae	11	28.6	4.4	R
190108	R Aquilae	11	11	7.5	L
			23	8.3	L
			28	8.6	R
		12	16	9.0	B
190926	X Lyrae	11	28	9.0	R
		12	22	8.5	M
191019	R Sagittarii	11	28	7.6	R
193449	R Cygni	12	4	12.6	Hu
			15	11.2	B
193732	TT Cygni	11	6	7.9	L
			28	8.5	R
		12	4	8.6	Ma
			4	8.0	Hu
			15	7.7	B
			21	8.0	M
194048	RT Cygni	11	28	8.4	R
		12	2	9.0	Ly
			3	9.1	O
			4	8.7	S
			4	8.6	Hu
			4	9.0	Ma
			5	9.2	O
			10	9.6	Bu
			12	9.4	Ly
			15	9.0	B
			21	9.3	M

Variable Star Observations Dec.-Jan., 1915-16—Continued.

194348
TU Cygni

Mo.	Day	Est.	Obs.
11	28	9.1	R
12	3	10.2	O
	4	8.3	Hu
	7	10.4	Ly
	10	9.8	Bu
	22	10.5	M

194632
χ Cygni

Mo.	Day	Est.	Obs.
11	12	10.4	L
	23	10.2	L
	28	9.9	R
12	3	9.8	O
	4	8.8	Hu
	5	9.8	O
	7	9.6	Ly
	10	9.6	Bu
	11	9.0	O
	12	9.4	Ly
	20	7.3	B
	21	7.4	M
	27	6.7	E

195116
S Sagittae

Mo.	Day	Est.	Obs.
11	28.6	5.6	R
	29.6	5.9	R
12	4.5	5.9	Ma
	5.4	5.4	O
	6.6	5.8	Mu
	7.4	5.7	O
	9.6	5.9	Mu
	11.5	5.4	O

195849
Z Cygni

Mo.	Day	Est.	Obs.
12	1	9.3	V
	7	9.2	Ly
	10	9.0	Bu
	15	8.4	B
	21	8.6	M

200357
S Cygni

Mo.	Day	Est.	Obs.
12	31	9.5	B

200647
SV Cygni

Mo.	Day	Est.	Obs.
11	6	9.4	L
	28	9.2	R
12	4	8.9	Ma
	4	8.2	Hu
	12	8.6	Ly
	15	9.0	B
	21	8.6	M
	31	8.9	Cr

200715 a
S Aquilae

Mo.	Day	Est.	Obs.
11	28	10.2	R
12	10	9.5	Bu
	16	9.5	B

200715 b
RW Aquilae

Mo.	Day	Est.	Obs.
11	28	9.2	R
	29	9.6	R
12	10	9.0	Bu
	16	9.2	B

200812
RU Aquilae

Mo.	Day	Est.	Obs.
12	16	11.5	B

200916
R Sagittae

Mo.	Day	Est.	Obs.
11	28	8.5	R
12	16	9.1	B

200938
RS Cygni

Mo.	Day	Est.	Obs.
11	6	7.3	L
	23	7.2	L
	28	7.5	R
12	4	7.9	Ma
	7	7.5	Ly
	10	7.2	Bu
	21	8.3	M

201521
RT Capric.

Mo.	Day	Est.	Obs.
11	11	6.9	L
	23	6.6	L
	29	7.8	R

201647
U Cygni

Mo.	Day	Est.	Obs.
11	6	9.3	L
	28	7.0	R
12	4	7.5	Cr
	5	7.3	O
	7	7.4	Ly
	9	7.8	Mu
	12	7.2	Ly
	21	7.2	M
	24	7.7	Mu
	27	7.4	Cr
	27	7.0	Mu
	27	6.8	G
	29	6.8	Mu
	30	7.4	Cr
	31	7.2	Cr

202539
RW Cygni

Mo.	Day	Est.	Obs.
11	28	8.7	R
12	4	9.1	Ma
	21	9.0	M

202646
RZ Cygni

Mo.	Day	Est.	Obs.
12	11	9.3	L

202954
ST Cygni

Mo.	Day	Est.	Obs.
12	4	11.5	Hu

202946
SZ Cygni

Mo.	Day	Est.	Obs.
11	28	10.5	R
	29	10.6	R
12	21	9.2	M

203847
V Cygni

Mo.	Day	Est.	Obs.
12	16	8.5	B
	21	9.5	M

204016
T Delphini

Mo.	Day	Est.	Obs.
11	28	10.2	R

204378
V Delphini

Mo.	Day	Est.	Obs.
12	3	10.7	O

205923
R Vulpec.

Mo.	Day	Est.	Obs.
11	28	9.0	R
12	4	8.3	Hu
	11	8.3	Hu
	22	8.8	M

210116
RS Capric.

Mo.	Day	Est.	Obs.
11	28	8.2	R

210868
T Cephei

Mo.	Day	Est.	Obs.
11	1	6.4	L
	15	6.3	L
12	7	6.3	Ly
	12	6.1	Lp
	15	6.3	Nt
	15	6.3	Bu
	27	7.0	Nt

213244
W Cygni

Mo.	Day	Est.	Obs.
10	22	5.7	L
11	6	5.8	L
	23	6.3	L
	29	6.3	R
12	11	6.3	L

213753
RU Cygni

Mo.	Day	Est.	Obs.
12	10	7.8	Ly
	21	8.4	M

213843
SS Cygni

Mo.	Day	Est.	Obs.
11	6.4	11.8	L
	11.3	11.8	L
	15.3	11.8	L
	23.3	11.8	L
	30.6	11.7	B
12	1.6	11.7	B
	4.6	11.8	Hu
	5.6	11.7	E
	7.6	12.1	Nt
	10.6	11.8	B
	11.3	11.8	L
	11.5	12.0	Hu
	11.6	11.9	Nt

SS Cygni

Mo.	Day	Est.	Obs.
12	12.5	11.9	Nt
	14.6	10.7	E
	15.5	8.7	Bu
	15.6	8.8	B
	15.6	8.6	M
	15.6	8.2	Nt
	16.5	8.6	B
	16.5	8.3	Bu
	19.5	8.7	B
	19.5	8.3	O
	20.5	8.6	B
	20.6	8.8	Hr
	21.5	8.7	B
	21.5	8.3	O
	21.5	8.4	M
	22.5	8.8	B
	22.5	8.5	Ma
	22.5	8.3	M
	22.6	8.5	E
	23.5	8.3	M
	24.5	8.9	B
	26.5	9.4	Bu
	26.5	9.0	Hu
	26.6	9.3	B
	27.5	9.5	B
	27.5	9.3	E
	27.6	9.1	Cr
	27.6	9.5	Mu
	27	9.5	G
	28.6	9.7	B
	29.6	9.4	Mu
	30.4	10.4	O
	31.5	10.5	B
	31.5	10.9	Nt
	31.6	11.1	Cr

213937
RV Cygni

Mo.	Day	Est.	Obs.
11	11	7.8	L
	29	8.6	R
	30	8.5	Ma
12	4	8.6	Ma
	4	8.0	Hu
	15	7.9	B
	21	8.2	M

215934
RT Pegasi

Mo.	Day	Est.	Obs.
12	15	9.2	Bu

220613
Y Pegasi

Mo.	Day	Est.	Obs.
12	16	9.5	B

220714
RS Pegasi

Mo.	Day	Est.	Obs.
12	2	9.0	V
	16	8.9	B
1	7	9.3	O

222439
S Lacertae

Mo.	Day	Est.	Obs.
12	31	12.6	B

225120
S Aquarii

Mo.	Day	Est.	Obs.
11	30	8.4	Ma
12	4	8.2	Ma
	18	12.9	B
	26	9.3	Hu

225914
RW Pegasi

Mo.	Day	Est.	Obs.
12	9	10.3	Mu
	21	9.4	M
	24	10.1	Mu
	27	9.9	Mu
	27	9.9	G
	29	9.8	Mu

230110
R Pegasi

Mo.	Day	Est.	Obs.
12	3	7.5	O
	4	7.5	Ma
	5	7.4	O
	10	7.5	O
	12	7.5	Ly
	15	7.3	Bu
	21	7.7	O
	21	7.3	M
	22	7.3	Ma
	29	7.4	Mu
	30	7.0	Nt
	30	7.7	O
1	6	8.1	O

230759
V Cassiop.

Mo.	Day	Est.	Obs.
12	11	9.6	O
	27	10.3	E
	31	10.7	O

233335
ST Androm.

Mo.	Day	Est.	Obs.
12	4	10.0	Hu
	10	10.4	Ly
	22	10.7	E
	30	10.6	S
1	6	10.7	O

233815
R Aquarii

Mo.	Day	Est.	Obs.
12	4	9.5	Ma
	26	9.2	Hu

235350
R Cassiop.

Mo.	Day	Est.	Obs.
12	15	8.0	Bu
	22	8.1	E
	30	7.6	Nt

235525
Z Pegasi

Mo.	Day	Est.	Obs.
12	2	9.2	V
	3	9.5	O
	27	8.8	E
	30	8.4	O
1	7	8.5	O

235939
SV Androm.

Mo.	Day	Est.	Obs.
12	4	11.0	Hu
	27	12.5	E

No. of observations 484; No. of stars observed 134; No. of observers 20.

We welcome as a member of the Association this month Mr. Nicholas D. Cheronis, "Ch", of the Lane Technical High School, Chicago, Ill. Mr. Hatcher's abbreviation for the reports will be "Ht" instead of "Hr", the abbreviation incorrectly assigned to him in the last report. "Hr" designates the observations contributed by professor Harrell, of Millsaps College, Jackson, Miss.

The December 6 issue of *The Independent* contained a brief account of the Association and the work we are engaged in, and brought us a number of requests for information concerning our organization.

Mr. Hunter calls attention to an error on the chart of the Variable 004533 RR Andromedae. The 11.6 magnitude comparison star lies between the 9.2 and the star now designated 11.6. It is a source of gratification that we are gradually eliminating the small errors in the charts that are bound to creep into such an extensive work

Mr. Lindsley deserves credit for the light curves derived from our observations that he continues to publish in POPULAR ASTRONOMY.

The historic variable *021403 o* Ceti has been exceedingly well observed during the past month, and although the calculated date of maximum is January 8, the observed maximum seems to have occurred during the third week in December. The magnitude at maximum was approximately 3.0

A long maximum of the variable 213843 SS Cygni was well observed during the latter part of December. Now that this variable will soon be too close to the sun for observation, our attention should be especially directed to the observation of the irregular variables 054319 SU Tauri, 060547 SS Aurigae, and 074922 U Geminorum. It is a good plan to observe these variables first each evening, then if clouds come up later you have secured the more important data.

The following calculated dates of maximum may be of interest. They are cited from the "Companion to the Observatory."

Jan.	8	015354	U Persei
	8	*021403*	*o* Ceti
	9	195849	Z Cygni
	12	*132606*	S Virginis
	13	*001909*	S Ceti
	20	084803	S Hydrae
	20	093934	R Leo. Min.
Feb.	3	194632	χ Cygni
	4	181136	W Lyrae
	6	*022000*	R Ceti
	15	134440	R Can. Ven.
	22	123307	R Virginis
	24	213678	S Cephei

The secretary will be glad to furnish observers at any time special charts they may require. The aim should be in every case to extend the observing list to cover as many variables as possible.

As the Secretary expects to be away from home in February, will members please endeavor to send their lists to him by the first day of the month.

The following members contributed to this report:—Messrs. Bouton, Burbeck, Crane, Eaton, Gray, Harrell, Hoge, Hunter, Lacchini, Lindsley, Mach, McAteer, Mundt, Nolte, Olcott, Pickering, Richter, Vrooman, Miss Swartz and Miss Young.

WILLIAM TYLER OLCOTT,
Corresponding Sec'y.

Norwich, Conn.
Jan. 10, 1916.

α Orionis.—In the November 1915 number of the *Observatory* is a brief article by an English Astronomer on α Orionis. He states that about the middle of October 1915 α Orionis was *fainter* than α Tauri (Aldebaran), and was nearly midway between α Tauri and γ Orionis. I cannot agree with him in regard to this. I have seen α Orionis *equal* to α Tauri, but never fainter. α Orionis early in

December was less than one tenth of a magnitude brighter than α Tauri, but since then it has brightened *very slightly*. I would like to have you ask the question of variable star observers in the next number of POPULAR ASTRONOMY if any of them have even seen this variable (*irregular*) *fainter* than α Tauri, and when.

F. E. SEAGRAVE.

Boston, December 24, 1915.

COMET AND ASTEROID NOTES.

Comet 1915 *e* (Taylor), Elliptic Elements.—In the *Lick Observatory Bulletin* No. 276 are given elliptic elements of comet 1915 *e*, computed by Ferd. J. Neubauer and H. M. Jeffers of the Berkeley Astronomical Department, University of California. The elements are based upon observations on December 7, 13 and 18. There is considerable discrepancy between the thirteen observations which cover the above interval, so that the elements are somewhat uncertain.

ELEMENTS.

$$T = 1916,\ \text{January } 27.906 \text{ Gr. M. T.}$$

$$\left.\begin{array}{l}\omega = 342^\circ\ 54' \\ \Omega = 114\ \ \ 52 \\ i = \ \ 14\ \ \ 30\end{array}\right\}\ 1916.0 \qquad\qquad \begin{array}{r}\mu = 669''.544 \\ \text{Period} = 5\ .299 \text{ years}\end{array}$$

$$\log q = 0.18170$$
$$\log a = 0.48282$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1916	True α	True δ	log Δ	Br.
	h m s	° ′		
Jan. 2.5	5 8 12	+ 8 10.3	9.7798	1.14
4.5	7 39	7 59.6		
6.5	7 14	9 50.2		
8.5	6 59	10 41.5	9.7849	1.13
10.5	6 54	11 33.3		
12.5	7 01	12 25.5		
14.5	7 18	13 17.8		
16.5	7 47	14 10.2	9.7984	1.07
18.5	8 28	15 02.4		
20.5	9 22	15 54.2		
22.5	10 27	16 45.6		
24.5	11 44	17 36.4	9.8182	0.98
26.5	13 13	18 26.4		
28.5	14 55	19 15.5		
30.5	16 49	20 03.6		
Feb. 1.5	5 18 55	+20 50.7	9.8428	0.88

An observation at Goodsell Observatory on January 6 indicates a correction of $-14^{s}.4$, $-5'.7$ to the ephemeris at that time. The observed position was as follows:

Gr. M. T.	α	δ	Observer
	h m s	° ′ ″	
Jan. 6.5833	5 06 59.08	+9 45 20.2	Wilson

The course of the comet during February will be between the horns of Taurus into the southeastern part of Auriga. Unfortunately no ephemeris is at hand for this month.

Comet 1915 *a* (Mellish).—This was easily visible in our 5-inch finder on January 7, the observed position being

Gr. M. T.	α	δ	Observer
	h m s	° ′ ″	
Jan. 7	3 24 42.15	+11 40 05.1	Wilson

No ephemeris for February is at hand.

COMMUNICATIONS.

Comet 1915 *e* (Taylor).—I wish to report that I observed Comet 1915 *e* (Taylor) on 1916 January 5^d 8^h.

At this observation I used a 4-inch telescope and while I found the comet from the ephemeris given in POPULAR ASTRONOMY after sweeping for about twenty minutes, yet I must say it was extremely faint. I doubt very much whether it can be seen at all with an aperture less than 4 inches.

WILLIAM H. CASSELL.

Wytheville, Virginia.
1916, January 6.

Internal Planetary Forces.—The force which occasions the sun-spots and that which makes its presence known upon our earth in the form of earthquakes and volcanic outbursts are so much alike, when due allowance is made for the physical difference of the bodies upon which the forces act, that one can with much certainty look upon them as the same phenomenon. Both forces act from within, both are periodic and both show a likeness in their periods as well as in their modus agendi.

Both forces act from within. The seismograph receives its vibrations from the body of the earth and leaves no doubt but that in regard to our planet the disturbance recorded is caused by an internal force. The volcano confirms us in this. Of all known forces acting upon the sun from without, the planets must exert the greatest force; but even these can, by their positions, be proven to have no connection with the topographical disturbances of that body. Hence, in this case too must we look for a force within.

Both forces are periodic. The sun-spot period of eleven years is well known. The earth's period of disturbance is about one hundred years, the great length of the period being due probably to the great surface-rigidity, which prevents the force from spending itself more quickly. During these periods, both upon the sun and upon the earth, we find a short period of quiescence followed by an outburst of longer duration, the two periods being constantly proportional to each other. Upon the sun the quiescent period lasts at an average for two years and upon the earth for about seventeen.

Both forces show a likeness in their periods as well as in their modus agendi. Taking D for the density of the celestial bodies, Pr for their period of axial-rotation and Pd for their entire period of disturbance, we find that, in the case of both earth and sun, the greater the quotient of $\frac{D}{Pr}$, the greater is Pd. If D be represented as one in the case of the earth, and Pr and Pd in hours, we find that their relationship upon the sun and the earth can be represented respectively, thus:

D/Pr	Corresponding *Pd*
$\frac{.25}{607} = .0004$	90,000 hrs.
$\frac{1}{24} = .04$	900,000 "

from which the following table can be developed:—

D/Pr		*Pd*
.000,004	=	9,000 hrs.
.000,4	=	90,000
.04	=	900,000

If now this force be considered as acting within other planets, we can compute approximately as follows:—

Sun's	*Pd*	is	90,000	hours
Mercury's	"	"	90,000	"
Venus'	"	"	89,000	"
Earth's	"	"	900,000	"
Mars'	"	"	890,000	"
Jupiter's	"	"	890,000	"
Saturn's	"	"	880,000	"

Concerning the remaining planets we can say nothing in this matter, their elements not being sufficiently known.

Still another likeness can be found in comparing the effects of this force upon the sun and upon the earth. The quiescent period is to the whole period as two is to eleven. From this we can conclude the following periods:—

Sun	2	years	of	quiescence	and	9	years	of	activity
Mercury	2	"	"	"	"	9	"	"	"
Venus	2	"	"	"	"	8¼	"	"	"
Earth	17	"	"	"	"	83	"	"	"
Mars	18	"	"	"	"	83	"	"	"
Jupiter	1½	"	"	"	"	99½	"	"	"
Saturn	18¼	"	"	"	"	83	"	"	"

George F. Kronenberger.

GENERAL NOTES.

Dr. W. W. Campbell, president of the American Association for the Advancement of Science, delivered an illustrated address on "The evolution of the stars," on the evening of January 3, the occasion being a special meeting of the Association held in Washington, D. C., January 3 and 4 in honor of the Pan-American Congress.

The New Bedford Astronomical Society of New Bedford, Mass., has purchased a 5-inch portable telescope, which they hope to use with much advantage when the weather and skies are suitable.

Observations on Mars at the Lowell Observatory during the present opposition show that the canal development strikingly corroborates the theory of seasonal dependence on the melting of the polar cap. The northern canals are now very dark indicating increased activity with advancing spring, while the southern canals are faint in their autumnal decline. The season in the northern hemisphere of Mars is now late April.

Recent Observations of Saturn at the Lowell Observatory show a remarkable change in the color and brightness of the planet's ball which is now of a pinkish brown tint and strikingly darker than the rings. Comparisons of the stellar magnitude of the planet with Capella, Procyon and Mars also show that its brightness is less than the predicted value in the ephemeris.

Saturn's Rings.—The last number of the memoirs of the Lowell Observatory announces a discovery in connection with Saturn. The investigation, by Director Lowell, is concerned with the theoretic and observed positions of the recently discovered as well as the old divisions of the ring-system. All of these divisions are caused by the perturbing action of Mimas on the particles of the rings. In consequence of their not quite agreeing with the theoretic positions an investigation was entered into which has succeeded in throwing new light on the internal condition and distribution of the matter composing Saturn's ball. The observed positions of these divisions can seemingly only be reconciled by a greater internal oblateness than has hitherto been supposed which demands a greater speed in the kernel than the husk. Not the least interesting fact about this result is that measures on the rings should lead to a discovery about Saturn's internal constitution.

Notes from the Yerkes Observatory.—The sky was less clear at night during 1915 than on the average. This was due to the more even distribution of the precipitation, of which the total was only slightly larger than the average. Rain fell on more days during the summer than usual.

The figures are, for observation with the 40-inch telescope at night, in 1915, 1602 hours; mean for the decade 1903-12, 1682 hours. The record is considerably poorer than for 1913, when there were 1822 hours; but much better than for 1914, when there was a very low record of 1480 hours.

The total precipitation recorded in 1915 amounted to 824 mm, as compared with the 10-year normal of 802 mm.

The Astronomical Club at the Observatory was favored with a most interesting lecture by **Dr. C. E. Kenneth Mees,** head of the Research Laboratory of the Eastman Kodak Company, on November 21. His topic covered a discussion of the gradation of plates and papers, of scale, and of resolvability of photographic plates.

Mr. Clifford C. Crump, who recently completed his work for the Doctor's degree at the University of Michigan, has been temporarily at the Observatory since the middle of October, as computer in spectroscopy, and has been engaged in measuring spectrograms. He begins his teaching at Carleton College on February 1, for the second semester.

Miss Harriet McW. Parson, who has a traveling fellowship from Vassar College, spent the autumn quarter at the Observatory. She will be occupied at the University of Chicago during the winter quarter, and will later return to the Observatory to complete her work for the Master's degree.

Mr. Julius Lemkowitz (B. S., University of Mississippi, 1915) has been engaged as temporary computer in spectroscopy since the end of the summer.

Mr. John E. Mellish has removed from Cottage Grove, Wisconsin, to Williams Bay, and is regularly sweeping the sky for comets, using various telescopes of the Observatory.

The Alvan Clark & Sons Corporation will continue its work under the direction of C. A. Robert Lundin, who for the past twenty years has been associated in the work of constructing the large objectives sent out by this firm.

The Spectrum of the Companion of Sirius.—Recent photographs of the companion to Sirius taken at the Mount Wilson Observatory seem to indicate that the line spectrum is identical with that of Sirius, but that there is a slight tendency for the continuous spectrum of the companion to fade off more rapidly in the violet region.

A Testimonial Dinner to Dr. John A. Brashear.—On November 24 Dr. John A. Brashear of Pittsburgh completed his 75th year. His many friends took advantage of the occasion to show him in what respect and affection he is held. A testimonial dinner was given in the largest dining hall in Pittsburgh and this was filled to the full by friends from far and near; indeed so great was the demand for tickets that a hall twice the size would not have sufficed for all who wished to be present. During the dinner a number of poems that had been written for the occasion were read, and a selection was made from the many telegrams and messages of appreciation that were received, including one from President Wilson, one from Governor Brumbaugh and others from distinguished friends in this country and abroad. The dinner was followed by a pageant representing some of the scenes in Brashear's life; his early struggles to become a maker of lenses while still laboring as a mill hand; the breaking of his first mirror after he and his devoted wife had worked upon it for several years; and his final triumph and entrance into the "world of light." This was followed by a procession of representatives of the many universities, societies and clubs with which Dr. Brashear has been affiliated. The rear of this procession was brought up by 75 members of the Phoebe Brashear Club. This organization is named for Mrs. Brashear, who died in 1910. Its membership is made up of teachers in the public schools of Pittsburgh, originally those who had received the benefits of the Educational Fund Commission, of which Dr. Brashear is the Chairman. Each of the members was clad in white and carried an American Beauty rose, which she presented to Dr. Brashear as the procession passed him, "A rose for every year." The celebration was brought to a close by an announcement on the part of the committee in charge, to the effect that a fund of $50,000 had been raised to establish a "John Alfred Brashear Lectureship" in Pittsburgh. The object is to attempt to perpetuate the valuable popular lectures on Astronomy and similar subjects that Dr. Brashear has been giving for many years, and always without financial recompense. Dr. Brashear himself is to hold this lectureship during his remaining years.

A Trans-Neptunian Planet.—Mr. Percival Lowell has recently published an important memoir on "A Trans-Neptunian Planet" in *Memoirs of the Lowell Observatory*, Vol. I, No. 1. He takes up an analytical study of the residuals between the observed places of Uranus from 1709 to 1910 and the theoretical positions calculated according to Leverrier's theory of Uranus of 1873 and according to Gaillot's later and more accurate theory. The residuals from Gaillot's theory are all under 2″.5, except that for the year 1752 which amounts to 4″.45, and the alternations of sign are such that one at first glance would not expect to find in them much evidence of the perturbative effect of an unknown planet. Mr. Lowell, however, by rigorous least square solutions finds that the sum of the squares of the residuals is reduced 71% on the hypothesis of an outside disturbing body in heliocentric longitude, July 0, 1914, about 84° or 263°. The two solutions give little choice between them. The first gives the smallest residuals, but the region of the ecliptic around and west of 84° is accessible to northern observatories and has been pretty thoroughly searched for many years. The other region is too low for northern observers and therefore is a better hiding place for an undiscovered planet. The results indicate an eccentricity of about 0.2 and, as large inclinations are usually associated with high eccentricities, one might expect an inclination of the orbit to the ecliptic of possibly 10°, which would make the planet the more difficult to find. The solution indicates for the unknown body a mass between that of Neptune and that of the earth; a possible magnitude of 12 to 13, according to albedo; and a disk of more than 1″ in diameter. Mr. Lowell emphasizes the uncertainty of his results by saying: "Owing to the inexactitude of our data, then, we cannot regard our results with the complacency of completeness we should like. Just as Lagrange and Laplace believed they had proved the eternal stability of our system, and just as further study has shown this confidence to have been misplaced; so the fine definiteness of positioning of an unknown by the bold analysis of Leverrier or Adams appears in the light of subsequent research to be possible only under certain circumstances. Analytics thought to promise the precision of a rifle and finds it must rely upon the promiscuity of a shot gun after all, though the fault lies not more in the weapon than in the uncertain bases on which it rests. But to learn of the general solution and the limitations of a problem is really as instructive and important as if it permitted specifically of exact prediction."

What is the Matter with Astronomy?—The following is from an editorial by Mr. Leon Barritt, publisher of the *Evening Sky Map*, in the January number of that publication:

"I am deeply interested in astronomy. I have found it a pleasurable diversion from the activities of a busy life, and I think every one should become acquainted with the "friendly stars." The facts are, however, that the subject receives comparatively little attention. I have found that astronomy is not taught in a single Grammar School in the United States. A few High Schools give it consideration in connection with physical geography, and in the Colleges and Universities it is elective, and very few take it up. In my boyhood astronomy was a part of the curriculum in every educational institution in the country. What has brought about this great change? I believe it is largely due to the abstract manner in which the subject has been presented in textbooks, making the subject repellent to teachers as well as students, and in no small degree has it been brought about by parents who want their children educated along lines that would have more commercial value. Statistics show that fully seventy five per cent of the children who graduate from the Grammar School do not enter High School, so this large percentage of boys and girls go out into life without the slightest knowledge of the great solar system of which we are a part. They know nothing of the apparent rising and setting of the sun, the cause of the moon's phases, or any of the simplest facts regarding astronomy.

"From these facts I am convinced that *The Evening Sky Map* has a most worthy mission in its endeavor to awaken and develop an interest in one of the grandest of sciences. I have been occasionally urged to enlarge it so as to publish longer articles. This I believe would be a grave mistake and defeat the purpose of the publication—that is, to present, at a low price, a monthly ready reference of the heavens, that can be carried in the pocket or hand bag anywhere. To increase its size would necessarily increase the cost to the subscriber. I can see no advantage in it. The field for the magazine for the advanced student in astronomy and for the professional astronomer is now amply and splendidly supplied in this country by POPULAR ASTRONOMY, published at Northfield, Minnesota. I have no desire to invade its field."

Resumé of Sunspot Observations at Mount Holyoke College, 1915.

Month	No. of Obs.	Days without	North of equator No groups	North of equator Av. Lat.	South of equator No. groups	South of equator Av. Lat.	Av. No. at each Obs.	New groups
Jan.	13	3	5	+18°.8	1	—21°.0	1.46	6
Feb.	15	1	6	20.8	10	19.1	3.47	16
Mar.	23	0	8	21.9	7	19.4	3.26	10
Apr.	21	3	5	22.0	8	20.4	2.19	10
May	21	7	6	20.5	3	16.3	2.05	6
June	13	3	6	17.3	5	19.8	1.92	9
Sept.	7	0	3	17.0	1	16.0	2.43	4
Oct.	13	0	7	18.1	3	16.3	2.69	9
Nov.	66	0	8	24.5	6	19.0	2.75	13
Dec.	10	0	4	15.8	5	18.8	2.50	8
	152	17	58		49			91

Average number at each observation	2.51
Average latitude of spots north of equator	+19.8
Average latitude of spots south of equator	—19.1

The method of observation was the same as that followed in previous years. During the first half year the record was kept by Miss Anna D. Lewis, Ph. D., during the second half year by Miss Louise F. Jenkins.

Anne Sewell Young.

Mount Holyoke College.

Publications of the Allegheny Observatory.—Three numbers 19, 20 and 21 of Volume III of the Publications of the Allegheny Observatory have just come to hand.

Number 19 contains tables for Parallax Factors in Right Ascension. These tables cover four pages and give the parallax factor parallel to the equator to two decimals with the horizontal argument ⊙, the longitude of the sun, for every hour; and the vertical argument $\odot - \alpha$ for every ten minutes from $5^h\ 20^m$ to $7^h\ 0^m$, and for every five minutes from $7^h\ 0^m$ to $10^h\ 25^m$.

Number 20 gives a discussion by Professor Schlesinger of the results of spectrographic observations of λ Tauri, indicating the presence of a third body in the system. λ Tauri is a well-known eclipsing variable star with a period of about four days. The third component is more distant than the second, probably about 4.5 times as far away, and has a period of 34.60 days. The mass of the distant satellite is very closely equal to two fifths of that of the eclipsing satellite. Under the most probable assumptions, the masses of the three bodies are respectively 2.5, 1.0 and 0.4 times that of the sun. The mean distances of these bodies from the centroid of the bright body and its eclipsing satellite are 3,200,000 km, 8,000,000 km and 50,000,000 km.

Number 21 gives a discussion by Zaccheus Daniel of the orbit and spectrum of VV Orionis. This is one of the stars whose spectra show oscillations of the hydrogen and helium lines while the K line of calcium, which is narrow and sharp, remains practically stationary. The orbit comes out circular, with a radius of about 2,700,000 km, orbital velocity about 132 km and radial velocity of the system +20.77 km. There is some evidence of a slow oscillation, produced by the disturbance of a third body, with a period of 120 days, but this is not very certain.

The velocity of the syetem obtained from the K line comes out +16.7 km, which is in close agreement with the velocities obtained for the same line in the spectra of δ and ε Orionis, which are in the same region of the sky and which exhibit the same phenomenon of sharp K lines, while the hydrogen and helium lines are broad. The simple mean of the K-line velocities from the three stars is + 16.8 km, which is very nearly the same as the motion of the sun away from that region of space. The hypothesis of a calcium cloud, stationary in space, between us and these stars, thus finds support. Whether the stars are in the cloud or not it is not possible to decide.

Dr. Coblentz' Measures of Stellar Radiation.—In the summer of 1914 Dr. W. W. Coblentz, of the U. S. Bureau of Standards, conducted some remarkable experiments in measuring the amount of radiation from various stars, by means of thermo-electric apparatus in connection with the 36-inch Crossley reflecting telescope at the Lick Observatory. The radiometer used was many times more sensitive than those previously used, and Dr. Coblentz was able to get measurable deflections of the galvanometer from stars as faint as 6.7 magnitude. He thinks, however, that much more sensitive apparatus must be constructed in order to study the radiation of fainter stars and the distribution of the energy of radiation in the spectrum. His discussion of the results is given in the *Lick Observatory Bulletin* No. 266.

From the measurements made on 105 stars Dr. Coblentz has drawn some very interesting conclusions. He finds that stars of the same brightness to the eye, but of different colors, have very different radiant energy. For example in the "Big Dipper" the yellow star α in the "pointers" is even fainter to the eye than the blue star ϵ in the "handle", but the total radiation emitted by the former is nearly double that of the latter. In general it was found that red stars emit from two to three times as much total radiation as blue stars of the same photometric magnitude.

By measurements of the radiations of stars and planets transmitted through an absorption cell of water it was found that, of the total radiation emitted, the blue stars have about twice as much radiation as the yellow stars and three times as much as the red stars, in the spectral region to which the eye is sensitive.

In the case of double stars with components of different color, the fainter component often emits the greater part of the total radiation.

In estimating the amount of stellar radiation falling upon the earth Dr. Coblentz finds the quantity "so small that it would require the radiations from Polaris falling upon one square centimeter to be absorbed and conserved continuously for a million years in order to raise the temperature of one gram of water 1° centigrade. If the total radiation from all the stars falling upon one square centimeter were thus collected and conserved, it would require from one hundred to two hundred years to raise the temperature of one gram of water 1° C. In marked contrast with this, the solar rays which reach the earth's surface can produce the same effect in about one minute."

The sensitiveness of the apparatus used was such that, when combined with the three-foot mirror, it should have registered a deflection of 1 mm when directed upon a candle placed at a distance of 53 miles. The sensitiveness required for satisfactory study of the distribution of radiant energy in the spectrum of the stars is about 100 times as great, i. e. the apparatus must yield a measurable deflection equivalent to that from the rays of a candle removed to a distance of 500 miles. Dr. Coblentz thinks this increase of sensitivity is possible, by the use of a 7-foot reflector and by increasing the sensitiveness of the radiometer (thermo-couple and galvanometer) twenty times.

Professor Edwin B. Frost, director of the Yerkes Observatory, has kindly communicated the following tabular summary of Dr. Coblentz' results, arranged in the order of the spectral class of the stars, which was used in presenting a discussion of the subject to the Yerkes Astronomical Club. It brings out very clearly the progression in total radiation with the order of spectral class B, A, F, G, K, M, N, and the accompanying color progression, from blue (Class B) to very red (Class N).

Summary, arranged according to Spectral Classes, of the Radiometric Measures on 110 Stars made by Dr. W. W. Coblentz with the Crossley Reflector at the Lick Observatory.

Note—In presenting to the Astronomical Club at the Yerkes Observatory the remarkable results obtained by Dr. W. W. Coblentz, of the Bureau of Standards, in his measurements with the thermopile of the total radiation of 110 stars, with the use of the Crossley reflector of the Lick Observatory during the summer of 1914, it seemed advantageous to collect the tabular data in a manner somewhat different from that given in Lick Bulletin No. 266 and in Bulletin No. 4, Vol. XI, of the Bureau of Standards. At my suggestion this was done by Mr. Julius Lemkowitz, computer in spectroscopy at the Yerkes Observatory. The galvanometric deflections obtained for the same star were averaged, and the results for the different stars were averaged by types and certain sub-types. For further advantage of comparison the deflections were also reduced to what they should be at magnitude 3.0. The name of the star, in the first column, is followed by its sub-class and magnitude, in the second and third columns; in the fourth column is given the galvanometric deflection, and in the fifth this deflection reduced to what it would be if the star's magnitude were 3.0. The means for each group are given below the group.

Edwin B. Frost.

Stars of Class B

Star.	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
γ Cassiopeiae	Bp	2.25	0.31 cm	0.16 cm
δ Scorpii	B0	2.54	0.54	0.35
β Cephei	B1	3.32	0.28	0.38
β Scorpii	B1	2.90	0.33	0.30
ζ Persei	B1	2.91	0.39	0.36
γ Pegasi	B2	2.87	0.33	0.29
δ Ceti	B2	4.04	0.08	0.20
γ Orionis	B2	1.70	0.91	0.27
η Ursae Majoris	B3	1.91	0.64	0.23
ζ Draconis	B5	3.22	0.32	0.38
ι Aquilae	B5	4.28	0.05	0.16
δ Persei	B5	3.10	0.44	0.48
β Librae	B8	2.74	0.47	0.37
ζ Pegasi	B8	3.61	0.15	0.26
β Persei	B8	2.6	0.77	0.53
β Tauri	B8	1.78	0.92	0.30
β Orionis	B8p	0.34	2.50	0.22
17 stars	B4	2.71	0.56	0.31
Omitting B8	B 2.5	2.70	0.35	0.29
B8	B8	2.21	0.96	0.34

Stars of Class A

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
α Lyrae	A0	0.14	3.54 cm	0.25 cm
α Pegasi	A0	2.57	0.31	0.21
α Coronae Borealis	A0	2.31	0.51	0.27
ζ Aquilae	A0	3.02	0.28	0.28
α Andromedae	A0	2.15	0.41	0.19
β Ursae Majoris	A0	2.44	0.37	0.22
γ Ursae Majoris	A0	2.54	0.27	0.18
ε Ursae Majoris	A0p	1.68	0.85	0.25
ε Herculis	A0	3.92	0.14	0.32
δ Herculis	A0	3.16	0.33	0.36
θ Aquilae	A0	3.37	0.22	0.31
ε Aquarii	A0	3.83	0.10	0.21
η Ophiuchi	A0	2.63	0.30	0.21
γ Aquarii	A0	3.97	0.24	0.60
ν Tauri	A0	3.94	0.12	0.29
α Cygni	A2	1.33	1.47	0.43
ζ Sagittarii	A2	2.7	0.33	0.25
α Piscis Australis	A3	1.29	0.90	0.19
α Ophiuchi	A5	2.14	0.64	0.29
α Aquilae	A5	0.89	1.73	0.53
δ Capricorni	A5	2.98	0.28	0.28
θ^2 Tauri	A5	3.62	0.18	0.32
22 stars	A 1.2	2.57	0.62	0.29

Stars of Class F

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
δ Aquilae	F0	3.44	0.30 cm	0.45 cm
β Cassiopeiae	F5	2.42	0.34	0.20
α Persei	F5	1.90	1.38	0.50
γ Serpentis	F8	3.86	0.32	0.70
γ Cygni	F8p	2.32	0.47	0.25
α Ursae Minoris	F8	2.12	0.60	0.18
6 stars	F 5.7	2.68	0.57	0.38

Stars of Class G

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
η Pegasi	G0	3.10	0.34 cm	0.37 cm
β Draconis	G0	2.99	0.44	0.44
ζ Herculis	G0	3.00	0.39	0.39
β Capricorni	G0p	3.25	0.50	0.63
β Aquarii	G0	3.07	0.55	0.58
α Aquarii	G0	3.19	0.69	0.82
α Aurigae	G0	0.21	6.14	0.47
γ Persei	G0p	3.08	0.72	0.77
γ Tauri	G0	3.86	0.36	0.79
η Draconis	G5	2.89	0.65	0.59
μ Herculis	G5	3.48	0.41	0.67
11 stars	G 0.9	2.92	1.02	0.59

Stars of Class K

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
α Boötis	K0	0.24	8.57 cm	0.67 cm
ε Pegasi	K0	2.54	0.82	0.54
α Serpentis	K0	2.75	0.62	0.49
ε Cygni	K0	2.64	0.60	0.43
α Ursae Majoris	K0	1.95	1.19	0.74
β Ophiuchi	K0	2.94	0.40	0.39
δ Draconis	K0	3.24	0.54	0.67
ε Draconis	K0	3.99	0.16	0.40
α Cassiopeiae	K0	2.6	0.57	0.39
γ Andromedae, A	K0p	2.2	1.4	0.67
ε Boötis	K0	2.7	0.83	0.63
ε Ophiuchi	K0	3.34	0.43	0.59
β Herculis	K0	2.81	0.48	0.40
β Aquilae	K0	3.9	0.30	0.69
β Cygni, A	K0p	3.24	0.50	0.62
ε Aquilae	K0	4.21	0.28	0.85
σ Ophiuchi	K0	4.44	0.37	1.39
ζ Cygni	K0	3.4	0.51	0.73
β Ceti	K0	2.24	0.86	0.43
δ Tauri	K0	3.93	0.52	1.22
ε Tauri	K0	3.63	0.35	0.72
γ Aquilae	K2	2.80	0.58	0.48
α Arietis	K2	2.23	0.35	0.17
γ Draconis	K5	2.42	1.62	0.94
γ Sagittae	K5	3.71	0.51	0.98
κ Serpentis	K5	4.28	0.57	1.85
α Tauri	K5	1.06	6.82	1.14
27 stars	K1	2.94	1.14	0.71

Stars of Class M

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
α Scorpii	Map	1.22	1.00 cm	1.94 cm
H.R. 7676 Draconis	Ma	5.43	0.15	1.41
δ Ophiuchi	Ma	3.03	1.12	1.14
δ Sagittae	Map	3.78	0.77	1.58
7680 Aquilae	Map	6.56	0.06	1.59
λ Aquarii	Ma	3.84	1.02	2.21
φ Pegasi	Ma	5.23	0.22	1.72
ν Ceti	Ma	4.18	0.31	0.92
α Orionis	Ma	0.14	19.14	1.38
α Herculis	Mb	3.48	6.40	9.97
6543 Ophiuchi	Mb	6.66	0.11	3.20
β Pegasi	Mb	2.61	2.84	1.98
12 stars	Ma	3.85	3.46	2.42

Class N

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
H.R. 9004, 19 Piscium	N	5.03	0.46 cm	3.83 cm

The Society for Practical Astronomy.—The following officers of this society have been elected for the year 1916-17:

President: LATIMER J. WILSON
Secretary: HORACE C. LEVINSON
Treasurer: H. W. VROOMAN

Councilmen:
- FREDERICK C. LEONARD
- JOHN E. MELLISH
- R. BURNSIDE POTTER
- A. F. KOHLMAN

Directors of the observing and other sections.

Planetary and Lunar: LATIMER J. WILSON
Solar: DAVID E. HADDEN
Spectroscopic: S. F. MAXWELL
Photographic: WILLIAM HENRY
Meteor: CHARLES P. OLIVIER
Comet: WILLIAM H. STEAVENSON
Aurorae, Zodiacal Light and Gegenschein: ALAN P. C. CRAIG
Nova Search: NELS BRUSETH
Instrument: M. THOMAS FULLAN
Practical Teaching: MARY E. BYRD

Editors:
FREDERICK C. LEONARD
HORACE C. LEVINSON

Librarian:
S. F. MAXWELL

Professor William H. Pickering, of the Harvard College Observatory Station at Mandeville, Jamaica, who has been contributing the "Monthly Reports on Mars," will coöperate with the Director of the Planetary and Lunar Section of the S. P. A. and will take charge of all of the work and observations on Mars sent by members of the above Section, or of the Society in general. The membership of the Society consists of about 115 persons, but it is always glad to welcome any new members and every active observer who wishes to join in ranks.

Dr. Mary E. Byrd's efforts to establish an "unofficial" Section for the Practical Teaching of Astronomy in the S. P. A. resulted in the establishment, on November 18 last, by the Council, of an official Section in the Society, and in her appointment as its Director. This Section offers a correspondence course in astronomy, and is flourishing in a most encouraging manner. All persons interested in its work, particularly teachers of astronomy, are cordially invited to correspond with Dr. Byrd on the subject, and to join the Society and its teaching section. Miss Byrd's address is Route 9, Box 77, Lawrence, Kans.

The Section for Construction of Astronomical Instruments, under the direction of Professor M. Thomas Fullan, of the Alabama Polytechnic Institute, now has its work well under way. Professor Fullan has written that he has the stencils for his mimeographed sheets of instructions all ready for the machine, and that the sheets will be sent out to members of the section, who expect to undertake the construction of their own telescopes, shortly after the first of January.

CONSTELLAR MOVIES.

One might suppose, at daylight's close, when stars come peeping thru
And seeming countless million orbs are blinking down at you,
That yon vast galaxy of suns were painted on a screen
And some mechanical device, somewhere behind the scene,
This panorama thru the sky moved steadily and slow,
With endless and untiring zeal, for watchers here below;
We train our lorgnettes on the scene and gaze to heart's content,
Awe-struck in profound reverence, and filled with wonderment;
We watch the Great Bear "loop the loop" around the Polar Sun,
While close Canes Venatici to Boötes' heels run;
The Little Dipper makes a "swoop" and skims the Arctic seas,
As Draco winds his coils about the feet of Hercules;
The Eagle of Aquila soars above Cygnus, the Swan,
And Berenices combs her hair a la Triangulum;
Miss Libra does a "balance all", Corona Borealis
Is wont to wear the "Northern Crown", Uranographers will tell us;
Monoceros, the Unicorn, with Crater quaffs the Po,
The Dog Stars at Columba bark, that sails above Argo;
Equuleus, to catch Pisces, with Musca baits his line,
The Dolphin trips Aquarius and spills his jar of wine;
Andromeda, the chained Queen, for Perseus shows her love,
Cassiopeia sits and frowns from her chair far above;
Proud Cepheus would a Monarch be; Lacerta does not care,
Sagittae wounds Vulpecula, but missed Pegasus' Square;
Camelopardus and Lynx Aries "points" defy,
And Cetus "sounds" (for he's a whale) as Taurus charges by;
Auriga's "kids" are out all night, as Gemini's Twins are.
Behold, Orion, with his club, drives Lepus to his lair;
Sly Cancer would "crab" Hydra's act, but Leo he butts in,
Virgo holds Corvus; Indus goes to bag the Serpent's skin;
Lupus encharmed by Lyra's harp, proposes to Pavo,
Volans takes wings and thus escapes a sting from Scorpio;
Old Ophiuchus, Scutum "shields" from Sagittarius,
But Piscis Australis falls prey to long-neck greedy Grus.
Betwixt Cancer and Capricorn old Sol is on the fly,
Projecting Zodiacal views—the "movies of the sky."

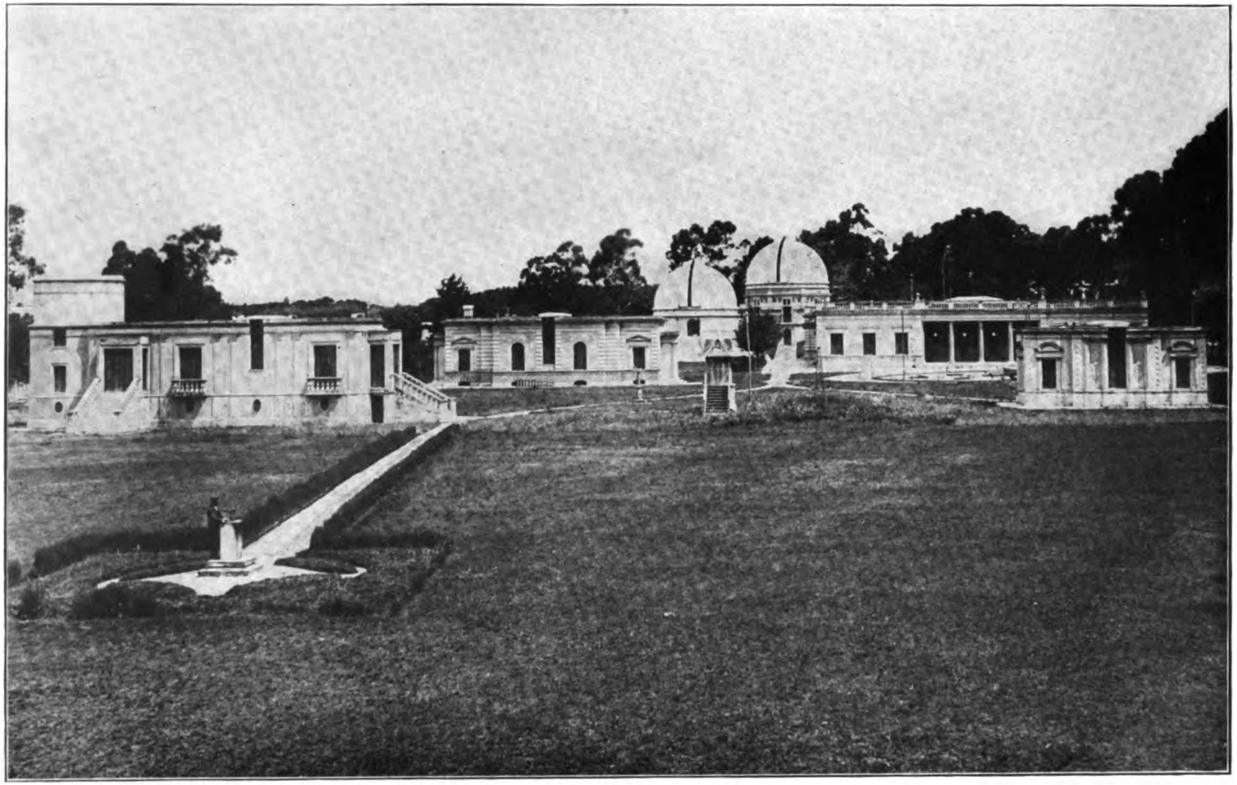
L. BERTON WILLSON.

Plenty of Space.

Penman—What's your brother doing now?
Wright—Oh, he's a space writer.
"Spăce writer?"
"Yes he's writing up astronomy."—

Yonkers Statesman.

PLATE V



General View of the Observatory of La Plata

Popular Astronomy.

Vol. XXIV, No. 3. MARCH, 1916. Whole No. 233

THE OBSERVATORY OF LA PLATA.*

W. J. HUSSEY.

There are more than 200 public observatories in the northern hemisphere and less than twenty in the southern. A large number of the northern observatories have been in existence many years. In general they have been well equipped for research and have had sufficient funds for the successful prosecution of their investigations. In the south, on the contrary, most of the observatories are of comparatively recent foundation and their funds have usually been small, though in some cases sufficient to enable them to make splendid contributions to science. From these circumstances it happens that astronomical investigations have been carried further in many directions on the northern than on the southern stars.

In the development of astronomy there is constant need of data from the entire sky. The existing southern observatories have not been able to supply their portions fully and in their need northern astronomers have at various times gone on expeditions to the southern hemisphere for the purpose of securing what they required. Thus, Lieutenant J. M. Gilliss, of the United States Navy, from 1849 to 1852, conducted an expedition to Chile to obtain meridian observations of Mars and Venus for use in connection with similar ones made at Washington for the determination of the solar parallax. Dr. B. A. Gould of Boston was in Argentina from 1870 to 1885, founding and directing the Argentine National Observatory at Cordoba, where he produced the *Uranometria Argentina*, the *Cordoba Zone Catalogue*, and the *Argentine General Catalogue* of stars, and where he established conditions which have since resulted in many important contributions to science. From 1908 to 1911 an expedition of the Carnegie Institution of Washington, consisting of ten astronomers headed by Professor Tucker of the Lick Observatory, working under the direction of Professor Boss of Albany, was in Argentina to determine anew the places of about 25,000 stars for the improvement of their positions and the determination of their proper motions. The Harvard Observatory has maintained a station at Arequipa, Peru, since 1889, for photometric and photographic work, the plates being sent to Cambridge for study, forming with those taken at the Harvard Observatory the largest existing library of astronomical negatives. Similarly, the Lick Observatory, since 1903, has maintained a station at Santiago, Chile, for stellar spectrographic observations, the plates being sent to Mount Hamilton for measurement. These have all been more or less American undertakings, though the results have been available to astronomers everywhere, for pure science has no national boundaries.

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* Reprinted from *The Michigan Technic* for December, 1915.

British and British Colonial initiative have given us the important southern observatories at the Cape of Good Hope, Melbourne, Sydney, Windsor, Perth, Adelaide, and just north of the equator the Indian observatories looking further into the southern skies than is possible from England. The observatory at the Cape of Good Hope, founded and maintained by the British Admiralty for obtaining data respecting the southern stars which can not be secured at Greenwich, has had a long and active career and a splendid record of achievement. Similarly the Australian and Indian observatories have done splendid work. The Australian observatories are at present largely engaged upon their assignments of the *Astrographic Catalogue.*

Notwithstanding all that has been done in the south, much still remains to be accomplished to bring our knowledge of the southern sky to the level of that of the northern. To aid in supplying what is lacking in one department, the University of Michigan, in 1910, through the generosity of Mr. R. P. Lamont, began preparations for southern work. To this end he provided the means for constructing a 24-inch refracting telescope, to be taken to the southern hemisphere when finished, for the discovery and measurement of double stars and for other observations. The completion of this instrument has been delayed, owing to failures of the glass makers to produce the disks of glass required for the objective. In the meantime an arrangement has been made with the University of La Plata which has enabled us to begin these observations at the Observatory of La Plata. It is a statement of this work that I have been asked to prepare for *The Technic.* It may not be amiss to give also a brief account of the Observatory of La Plata, which today has the largest and best equipment of any observatory in the southern hemisphere.

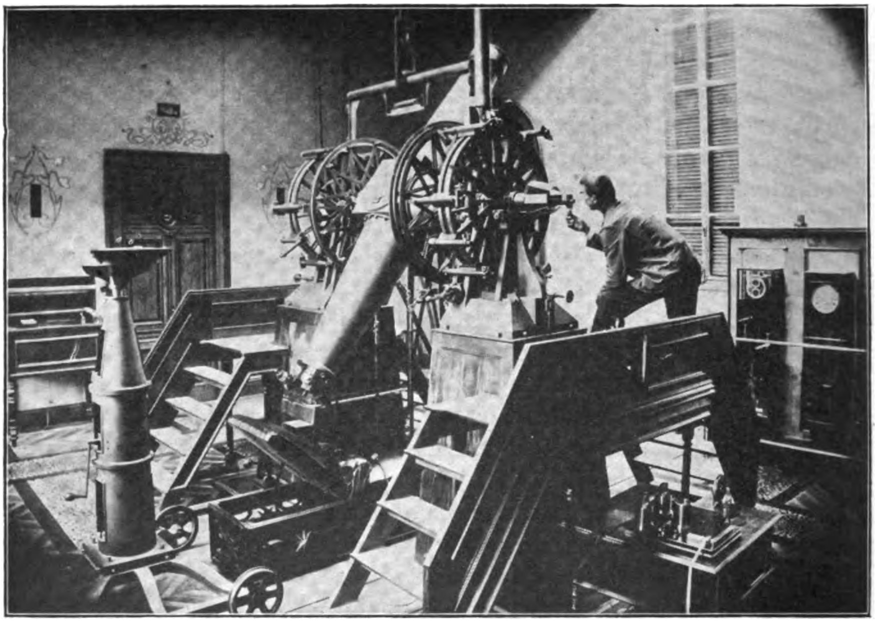
La Plata, with a population of somewhat more than a hundred thousand inhabitants, is the capital of the Province of Buenos Aires, the the largest and richest of the Argentine states. It was founded in 1882, soon after the nation had appropriated the city of Buenos Aires and the region immediately about it to be the seat of government of the republic. La Plata was planned on a generous scale, with broad streets and intersecting diagonals, after the fashion of Washington, and it was quickly built, with imposing public buildings, well-paved streets, and ample parks. Among the institutions established here at the cost of the Province at the epoch of the creation of the city are the University, the Museum, the Observatory, and the College of Agriculture and Veterinary Science. All of these have since been transferred to the nation and are now departments of the new National University of La Plata.

The Observatory of La Plata was founded in 1882. By successive decrees of the Executive Power of the State, during the next six years, authorization was made for the purchase of a complete and varied collection of astronomical instruments and for the construction of the buildings which would be necessary for their installation. Fifteen buildings were erected and the instruments obtained during that period were the following: Two refracting telescopes, one of 8.4 and the other of 17 inches aperture; two meridian circles, one moderately small and the other one of the largest and most complete in the world; two astronomical transit instruments for time and latitude observations; a large and very complete altazimuth instrument; a reflecting telescope of 31.6 inches aperture; a photographic refractor of the astrographic type of 13.5 inches aperture; and many smaller instruments, including clocks, chronometers, chronographs, etc. All of the original equipment was purchased in France and the instruments were the best obtainable at that time.

It was several years after the large instruments were ordered before they were completed and delivered. And more years passed before the buildings were finished and the instruments installed and made ready for use. In the meantime a period of great financial depression had come to the country and the Province was seriously affected. There were years of waiting in which no one knew whether the next would be better or worse. It was a time when constructive statesmanship was needed. In the emergency, through the efforts of Dr. Joaquin V. Gonzalez, then a member of the federal cabinet as Minister of Justice and Education, various institutions at La Plata which had been founded and maintained by the Province were transferred to the nation as Departments of the new National University of La Plata. Soon after the Observatory of La Plata passed under the control of the University, in 1906, its staff was reorganized and a considerable number of additional instruments were purchased. Among these were two zenith telescopes and a large meridian circle of the latest pattern from the celebrated house of A. Repsold & Son; a zenith telescope from

Bamberg; a large comet seeker from Zeiss; an international latitude instrument from Wanschaff, and a number of smaller instruments, such as seismographs, computing machines, comparators, etc.

After a time further administrative changes became necessary and in 1910 I was asked to reorganize the staff and assume the direction of the scientific work. On taking charge of the Observatory in the following year I found a large collection of excellent instruments, more than we could expect to use constantly. Definite lines of work had therefore to be selected, appropriate to the instruments and to the men. Some time was spent in studying the situation, in making arrangements for increase of staff, in securing appointments, in improving sanitary conditions, and in making those indispensable adjustments and alterations which invariably have to be made in putting instruments into commission and rendering them efficient. Observations have now been in progress a sufficient time to furnish results and these are in every way satisfactory. The larger pieces of work are being done with the large Gautier meridian circle, with the large equatorial, and with the comet seeker, and of what has been done with these I shall speak particularly. In passing it may be remarked that occasional use has also been made of the Astrographic refractor, the Wanschaff zenith telescope, the small equatorial, and one of the Repsold transit instruments.

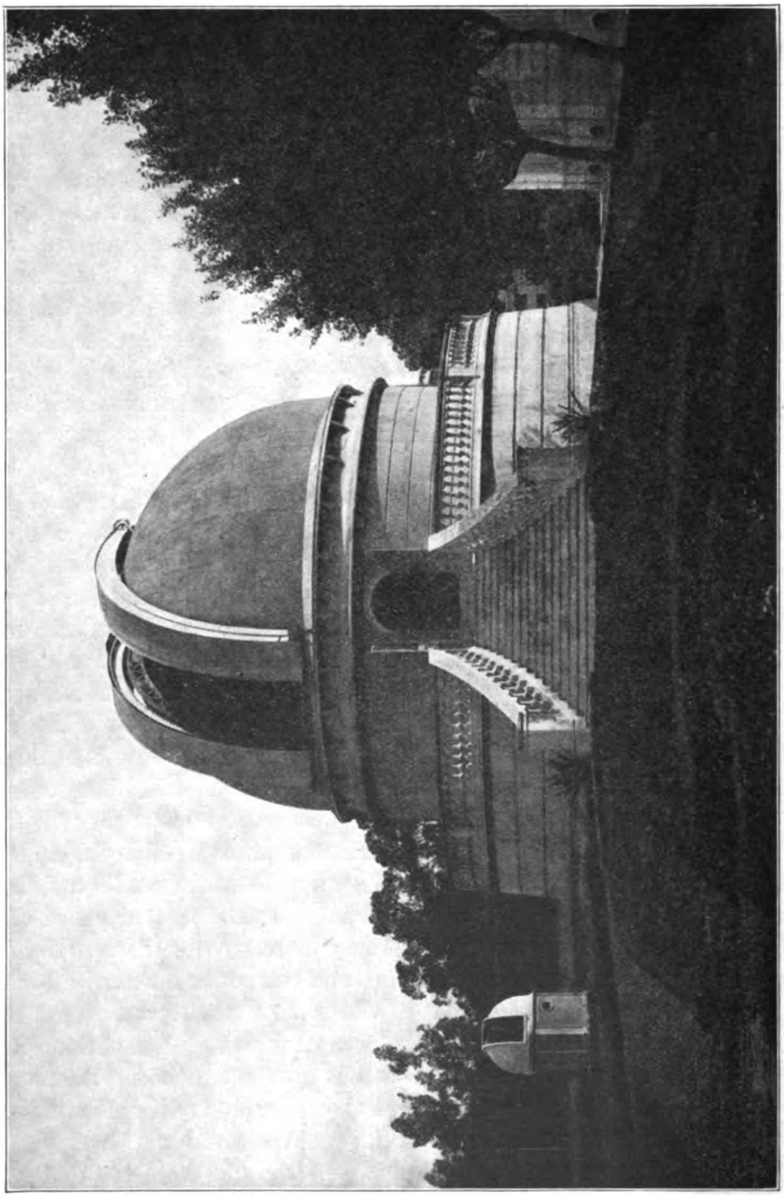


GAUTIER MERIDIAN CIRCLE.

In 1913, Astronomers Felix Aguilar and Paul T. Delavan, after some preliminary practice to familiarize themselves with the instrument, began an extensive series of observations with the large Gautier meridian circle. Their object is to determine the exact places of about 15,000 southern stars or all of those to the ninth magnitude inclusive, which are situated in a zone ten degrees wide, comprised between the declinations −52° and −62°. They have already secured about twenty-five thousand observations on this program, or somewhat more than half the number that will be required. If the work be continued at the present rate the observations needed to complete the program will be nearly or quite obtained by the end of 1916. The positions of many of these stars have never before been accurately measured. They are needed for various astronomical investigations. The observations will also furnish data for improving the positions of the brighter stars of the zone. They are situated not far from the zenith of the southern countries, and will be useful for geodetical operations, such as determinations of time, azimuth, and latitude.

In this connection it may be stated that the meridian work at La Plata is an extension of that begun about 1870 by the coöperation of northern observatories, which has resulted in the production of a most valuable series of star catalogues, viz., the so-called *Astronomische Gesellschaft Catalogues.* Nineteen volumes of these catalogues have been printed, giving the exact places of all stars to the 9.0 magnitude inclusive from 80° north declination to 18° south declination. The coöperating observatories in the United States were those at Albany, Cambridge (Harvard), and Washington, and in Europe those at Berlin, Bonn, Cambridge (England), Christiania, Helsingfors-Gotha, Kasan, Leiden, Leipzig, Lund, Nicolajew, and Vienna, and in Africa, Algiers. The results from all of these observatories except Algiers have been printed, and those from Algiers are nearly ready. In general each observatory took a zone five degrees in width, and in no case were the observations of a zone completed in less than four years, and generally the time taken was considerably more. After the completion of its first zone, Harvard took a second, and the zones for Berlin, Bonn, and Leipzig were each ten degrees in width. In the south the Argentine National Observatory at Cordoba has completed the observations for three five-degree zones, and La Plata is making the observations for two such zones. The observations already secured at La Plata are more than would have been required for a single zone.

The calculations giving the final places of the stars from the La Plata measurements are following the observations closely. The probable errors of the results are in general smaller than those ordinarily obtained in differential work, which speaks well for the La Plata



REFLECTOR DOME AND COMET-SEEKER.

meridian circle and for the skill of those who are using it; viz., the observers, Messrs. Aguilar and Delavan, and their assistants, Messrs. Chaves, Crump, Boero, and Manganiello.

On taking charge of the Observatory of La Plata, toward the end of 1911, I began to use the large refractor for the discovery of double stars. In the following year when a micrometer had been fitted to it so that measurements could be made, the instrument began to be used for the observation of double stars, comets and minor planets. More than three hundred double stars have been discovered with it, including some fine pairs, with small distances, which are likely to prove interesting binaries. More than three thousand observations of double stars have been made, about a thousand by myself, and the rest by Astronomer B. H. Dawson, during his two years of residence at La Plata. He devoted his attention to the measurement of pairs already known and to the verification of their positions in the sky. Much must be done in this way before we shall be able to draw definite conclusions respecting the number, distribution, and character of the southern double stars.

Since 1912 nearly four hundred observations of comets and of the minor planet *Interamnia* have been made with the large equatorial. Twelve different comets have been observed. Three of these were discovered at La Plata by Mr. Delavan, who regularly devotes a portion of his time to searching for them with the Zeiss comet-seeker. The first comet found by him was a return of Westphal's comet of 1852, whose period was so imperfectly determined that it was not known when or where it would reappear. The observations made subsequent to its rediscovery have removed the uncertainties respecting its orbit and its path is now accurately known. The second comet found by him was new and has now been under observation nearly two years, an apparition of longer duration than for any other comet. It was found ten months before it reached perihelion, when at a distance of about 400,000,000 miles from the sun. Very few comets are visible at such distance. For several weeks in the latter part of 1914 it was a conspicuous object to the naked eye in the northern sky. At that time it was photographed at Ann Arbor by Mr. Mellor and some excellent spectrograms of it were obtained with the large reflector by Dr. Curtiss. The comet is now in the southern sky, a telescopic object. It is not possible to say how long it will remain visible, for comets are subject to sudden and unexpected changes in brightness and physical appearance. If it follows an orderly course, however, it will be observable with large telescopes several months longer, making its apparition notable by reason of its great duration.

I will mention only a few of the miscellaneous undertakings at La Plata, in many of which Mr. H. J. Colliau took an active part. These relate to the betterment of living conditions, the maintenance of buildings and grounds, the care and improvement of instruments, and to the routine operations which are inseparable to the conduct of an Observatory. An excellent instrument shop was built and equipped, a sewer constructed, buildings and domes repaired and painted, alterations made in the meridian circle and other instruments, a Riefler clock and seismographs installed, and the Latitude Observatory moved from Oncativo. The usual meteorological observations have been made continuously, and time signals have been sent regularly to the ships at Ensenada, the port of La Plata, and to the Argentine navy at Bahia Blanca.

Enough has been done at La Plata during the past four years to make a good record and to secure for the institution a creditable place among the working observatories of the world.

THE WINTER MOON.

O gem of gems amid a starry sky!
    Like jewel set within the dome of night
Or shining mirror seen afar and nigh,
    Whose sunlit splendor veils the stars from sight;
Celestial pearl!—resplendent to the eye
    When earth is barren with chill winter's blight,
When Queen Capella's beacon blazes high
    And Sirius pours forth his royal light;
Upon our world of human joy and sigh
    Yon moon of winter rises full and bright,
On wooded knolls her beams in splendor lie,
    On frozen fields that sleep so stark and white;
O gem of gems amid a starry sky,
    With here and there a lone cloud drifting by!

CHARLES NEVERS HOLMES.

Hotel Nottingham, Boston.

THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

[*Continued from page 96.*]

THOMAS HARRIOT.

Thomas Harriot, the second to observe the solar spots with the telescope was born at Oxford in 1560. He became tutor to Sir Walter Raleigh, and was appointed by him to the office of Geographer to the second expedition to Virginia. After his return he lived under the immediate patronage of Henry, Earl of Northumberland, part of the time at Petworth in Sussex, and part at Syon House, the seat of the Earl on the Thames near London. He died at London in 1621.

We are indebted to Baron Zach for calling attention to the astronomical observations of Harriot. Zach obtained access to the Harriot manuscripts in 1784, while visiting in England. He proposed to the University of Oxford to prepare a portion of them for the press, if they would undertake the expense of the publication. This they immediately agreed to do, but for some reason Zach failed to do his part and the publication never appeared. After a lapse of eight years, in 1794, Zach forwarded to the press, not the work which he had promised, completed and ready for printing, but simply a number of the original manuscripts without any of the statement which he was to have drawn up concerning them. In the mean time, Zach published in the *Berliner Jahrbuch* for 1788* an account of these papers, which, from the many inaccuracies in it, must have been drawn up from loose memoranda. It is easy to understand that the pleasure of the discovery might have led Zach to over-estimate what he had found; but it is hardly adequate to account for the very erroneous statement of facts which he gave, and which may be attributed to an imperfect recollection of the details which he was attempting to describe.

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* Page 153.

To return, however, to 1794. The delegates of the press had every wish to promote the publication, but things were materially altered. The press was placed in a situation in which it was responsible for working up the material which Zach had thought proper to select. Hence it became necessary for those who acted for the University to take the precaution of inquiring further and ascertaining the character and nature of what had been put into their hands. Dr. Robertson, the Savilian Professor, was therefore requested to make a report on these papers. Robinson's report* was that the papers were from no point of view worth publishing. Concerning the sun-spots, Robertson states:

> From these papers it appears that he first began to observe the spots on the sun on the 8th of December 1610, and that he continued to observe them at irregular intervals, to the 18th of January 1613. The observations recorded are 199 in number, and the accounts of them are accompanied with rough drawings representing the number, position and magnitudes of the spots.

For the most complete account of Harriot's observations we are indebted to S. P. Rigaud, the successor of Robertson. Rigaud obtained access to the manuscripts and published an extensive account of them in his *Supplement to Dr. Bradley's Miscellaneous Works*, published at Oxford in 1833.

Harriot's observation included five different subjects; I. Halley's comet; II. The moon; III. The satellites of Jupiter; IV. The spots on the sun; V. The comet of 1618.

Of most interest to us are the observations of the spots on the sun. They are 200 in number, and are contained in 73 half-sheets of foolscap besides three smaller pieces of paper. The first observation was made on the 8th of December (O. S.). The record of this observation and several later ones as found on the first of the half-sheets is as follows, (Plate VI):

> 1610 Syon December 8^{d} mane. The altitude of sonne being 7 or 8 degrees.
>
> It being a frost & a mist. I saw the sonne in this manner.
>
> Instrument. $\frac{10}{1}$ B. I saw twise or thrise. once with the right ey & other time with the left. In the space of a minute time. after the sonne was to cleare.
>
> $\frac{1610}{1611}$ Syon. January 19th. A notable mist. I observed dilligently at sondry times when it was fit. I saw nothing but the cleare sonne both with right and eft ey.
>
> Syon. 1611. Decemb. 1 ⊙ mane. ho. 10. 0. per horologium solare.
>
> I saw three blacke spots in such order as is here expressed as nere as I could judge. observed $\frac{10}{1}$. S^{r} W Lower. with Chr. also saw the same. at sundry times all three were seen & observed at once for halfe an houre space. at which time and all the morning before it was misty.
>
> The greatest was that which was most oriental appearing somewhat ragged, and was of apparent angle about 2′, the other two, were nere of one bigness: & of 1′ magnitude, or there aboutes.

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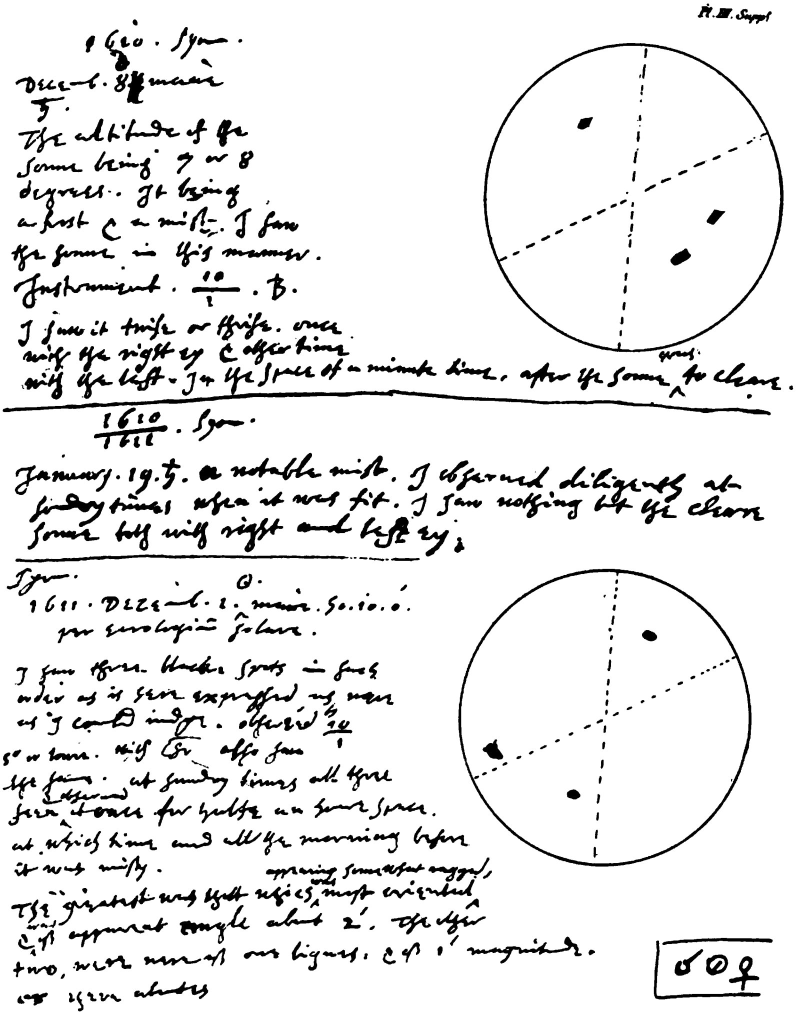
* *Edinburgh Philosophical Journal* 6, 314, 1822.

PLATE VI



H.M. Suppl

1610. Syon.
Decemb. 8. mane
♄.
The altitude of the
sonne being 7 or 8
degrees. It being
a frost & a mist. I saw
the sonne in this manner.
Instrument. $\frac{10}{1}$. B.
I saw it twice or thrice. once
with the right ey & other time
with the left. In the space of a minute time, after the sonne grew to cleare.

$\frac{1610}{1611}$. Syon.

January. 19. ♄. a notable mist. I observed diligently at
sundry times when it was fit. I saw nothing but the cleare
sonne both with right and left ey.

Syon.
1611. Decemb. 1. mane. 9.10.0.
per horologium solare.

I saw three blacke spots in such
order as is here expressed as neare
as I could judge. observed $\frac{10}{1}$
20 or more. with [illegible] also saw
the same. at sundry times all three
seen at once for halfe an houre space.
at which time and all the morning before
it was misty.
The greatest was that which was most oriental appearing somewhat angular,
& of apparent angle about 2'. the other
two, were neare of one bignes. & of 1' magnitude.
or [illegible]

♂ ⊙ ♀

Fac-simile of Harriot's First Observations

In the entry of the first observation there is no description or mention of the spots, but accompanying it is a sketch representing the sun and showing three spots on its surface. From the wording of the entry one gathers the impression that Harriot had unexpectedly seen something entirely novel to his experience. To make sure of its reality he examined it several times with each eye, until the brightness of the sun prevented further investigation. Apparently the observation was not repeated until the 19th of January 1611, at which time the sun was unfortunately free from spots; in consequence, Harriot did not again observe the sun until the following December. Rigaud suggests that his attention may have been recalled to the sun by a conjunction of Venus and the sun which was expected to take place on the 11th of the month. While the date on which the spots were first seen by Harriot is December 8th, 1610; the first numbered observation of the series is that of December 1, 1611; the last observation (numbered 199) is dated January 18, 1613. Rigaud is not inclined to consider Harriot's observation of the spots on the 8th of December 1610 as a real discovery, since the phenomenon is not designated by a specific name until the later observation of December 1611. He writes:*

> ......he appears to have had no appropriate terms in which he could describe them, and merely refers to the drawing for the appearance which he was desirous of recording. His earliest observation indeed was no more than a transient view of a phenomena, which had been seen before his time, even with the naked eye; and......I must say that it is a misapplication of terms to call such an observation a discovery.

This is evidently the origin of the statement which has found its way into Grant's *History of Physical Astronomy*. After stating that Zach from his examination of the manuscripts concluded that Harriot had observed the spots as early as the month of December 1610, and that Rigaud subsequently found that the observations would not bear the interpretation put upon them by Zach, Grant states:†

> It turns out in fact from his researches, that Harriot did not commence his observations of the spots before the month of December 1611.

A statement, which while strictly true as far as it goes, is not the whole truth and is hence misleading. Just what constitutes a discovery is a subject that will admit of considerable discussion. If we accept the above criterion, Columbus would hardly be allowed the credit for the discovery of America, for he had no intention of finding a new continent, and it is certain that he had no intimation that it was a new continent when he first saw it.

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* *Supplement* p. 37.

† Page 215.

There is every reason for believing that Harriot had no previous knowledge of the existence of the spots. As we shall see later, there was no published statement in Europe of the existence of the spots prior to the fall of the year 1611. Therefore Harriot's first observation must be considered as having been made absolutely independently. Baron Zach, however, claimed that Harriot had been influenced by Josephus Acosta's *Natural and Moral History of the West Indies*, in which Zach evidently believed it to be related that in Peru spots were seen on the sun which were not to be seen in Europe. This is an error, which unfortunately seems to have found its way into various histories. The statement in Acosta is as follows:*

> I say moreover, to confirm this truth, that the heavens move and in them the starres march in turning, the which we cannot easily discerne with our eyes, seeing we see that onely the starres do move, but also the regions and whole parts of heaven; I speake not onely of the shining & most resplendent parts, as that which we call Via Lactia, and the vulgar, S. Jaques way, but also of the darker & obscurer parts in heaven. For these we see really, as it were spots and darkness, which are most apparent: the which I remember not to have seen at any time in Europe, but in Peru, and in this other hemisphere I have often seene them very apparent. These spots are in colour and form like unto the Ecilps of the Moone, and are like unto it in blackness and darkness: they march, fixed to the same starres, alwais of one forme and bignes, as we have noted by infallible observation.

From which it is seen that the spots referred to by Acosta were certainly not in the sun, but were evidently the dark regions which are so conspicuous among the constellations of the southern sky.

Harriot's observations are of particular interest historically, for they are the earliest original drawings of the sun-spots made with the telescope. Scheiner's first drawings are of a later date and accompany the third letter to Welser; the series begins with the 21st of October and continues to the 14th of December 1611.† The first drawings of Galileo were made still later, on April 5th, 1612, accompanying the first letter to Welser‡. But even previous to Scheiner's drawings, Ludovico Cardi da Cigoli had sent Galileo a rough sketch of the spots with the letter dated the 16th of September 1611 ¶.

Apparently Harriot was unacquainted with the method of observing the sun by projecting an image on a screen through a small opening, as we shall see was done by Fabricius, or by projecting it with a telescope as was done by Galileo and Scheiner. He does mention once, however, of "observing through my coloured glasses" (December 13, 1611).

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* *The Naturall & Morall Historie of the East and West Indies*, 4to. London 1604. Booke I. Chap. 2. p. 8.

† Reproduced in *Gal. Op.* **5**, 32-33.

‡ Reproduced in *Gal. Op.* **5**, 107.

¶ Reproduced *Gal. Op.* **11**, 208.

It seems from the notes accompanying his observations that he was accustomed to observing through thin clouds or fog, and at times when the sun was near the horizon. We find such statements as, "The sonne was somewhat to cleare, there being no cloudes but only a thick ayer;" "Thick ayer and thin cloudes;" "A thin mist and thin cloudes." His drawings were made with common pen and ink and show no shading, but he repeatedly mentions that spots and parts of spots are "dim", or not as dark as the remainder. He also noticed that the spots appeared larger when near the center of the disk. "They generally seeme bigger, being nere the middle then the sides," (December 15, 1611).

Harriot evidently did not believe that the spots were planetary bodies. It may be possible that he succeeded in determining the period of the sun's rotation to be about 27 days; there are certain calculations on his papers which seem to indicate this, but there is considerable difficulty in interpreting these calculations and the reasoning by which the period of 27 days was deduced.

JOHANN FABRICIUS.

Johann Fabricius, the author of the first printed publication mentioning the solar spots, was born January 1587, at Resterhave, near Dornum in East Friesland. His father, David Fabricius, to be remembered for his discovery of the variability of Mira Ceti in August 1596, was a Protestant preacher, astrologer and astronomer. The father was an intimate friend of Kepler, and in spite of astrological hobbies, was considered by him upon the death of Tycho Brahe as belonging in the first rank of observational astronomers. The correspondence between David Fabricius and Kepler bears witness that Fabricius furnished Kepler with valuable observational data which were used by him in the computations on the orbit of Mars. It is curious that, notwithstanding his intercourse with Kepler, the elder Fabricius did not adopt the Copernican theory, but adherred to that of Tycho Brahe. That he was alert, and kept pace with the advancement of learning is evident, for this country parson, living in an out of the way corner of Europe was one of the first to apply the newly invented telescope to the study of the heavens. He was the author of a number of publications, astronomical and partly astrological; most of these have become lost, the remainder are rarities of the first order.

Johann Fabricius was the eldest son of seven children. We have but scanty information concerning his youth. It seems that he entered the University of Helmstedt as a student of medecine in May 1605. Evidently he did not remain long, for a year later he matriculated at the University of Wittenberg; but whether as a student of medicine or not, we do not know. Three years later he registered as a student of medicine at the University of Leyden. It was at Leyden apparently, that he became acquainted with the telescope. This he later brought to his father's house at Osteel, at which place the first observations of the spots were made. Upon completing a series of observations under the direction of his father, he collected the results into a small pamphlet and returned to Wittenberg where the pamphlet was subsequently published. From the records of the University of Wittenberg, we learn that Johann Fabricius was awarded the degree of Magister Philosophiæ in September of the same year (1611). He apparently obtained no degree for the studies in medicine.

The published pamphlet bore the title:

JOH. FABRICII PHRYSII

De

MACULIS IN
SOLE OBSERVA-
TIS, ET APPARENTE

earum cum Sole conver-
sione,

NARRATIO

cui

Adjecta est de modo eductionis specie-
rum visibilium dubitatio.

VVITEBERGAE,

Typis Laurentij Seuberlichij, Impensis Iohan. Bor-
neri Senioris & Eliæ Rehefeldij. Bibliop. Lips.

……………………………………………

ANNO M. DC. XI.

The pamphlet consisted of 22 unnumbered leaves in 4to. The dedication reads; "Illustri et Generoso Domino Dn. Ennoni,……Dabam VVitebergæ Anno Aeræ Dionys. 1611. Idib. Iunii. Tuæ Celsis Subiectiss. Cliens Johannes Fabricius."

Of the subsequent events in the life of Johann, we know practically nothing. The *Narratio*—a publication of the highest interest—containing the first printed account of an important discovery with the newly invented telescope, was not only forgotten, but practically vanished, and that in a very short time. Similarly all traces of the author disappeared, and we only learn of his untimely death through Kepler who, expressing his sympathy, refers to the death of Johann in the *Responsio ad Interpellationes Davidis Fabricii.*[*]

> Nay more, having read your *Prognosticon* for 1618 [which is now lost to us] by which I was informed of his untimely death, I add the announcement of my grief. Because I perceive that you, my friend, have lost a good son, and that philosophy has lost a most industrious disciple, fondest of truth and freedom of thought, and that I have lost my dear friend. But of course there remains his little book on the sun-spots, published in 1611, more productive of praise than any elegy or epitaph, which contains an assurance of his fame after death, and a solace for our common grief.

A prediction which has been wholly verified. The exact date of Johann's death is not known, but it must have occurred during the period from March 1616 to May 1617.

Only a portion of the subject matter of the *Narratio* has any particular reference to astronomical observations. As De la Lande views it, "the remainder is a verbiage of metaphysics, useless for our purpose."

Stimulated by the success with which Galileo has been rewarded for the use of the telescpe in astronomical observations, as learned from the *Siderius Nuncius*, Johann Fabricius commenced using this instrument himself with the expectation of speedily making the discovery of something new. As Jupiter and the moon had been sufficiently scrutinized, he sought new fields to conquer and selected the sun. The circumstances of his discovery of the spots are told as follows:[†]

> Finally I hit upon a course with reference to the sun, pursuing which, I beheld the sun from a distance like a circle of great size, or the terrestrial globe. It seemed to be also now and then rough and uneven near the edge, which, as I had learned from letters of my father David Fabricius to me, had also been observed by him, though not so distinctly. However, since I am unable to speak with certainty on this point, it deserves further and more careful observation, a thing not difficult for him who uses a better telescope. While observing these things carefully a blackish spot suddenly presented itself, on one side indeed rather thin and faint, of no little size compared to the disk of the sun. I had at first no little doubt in the

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[*] *Ephemerides Novae Motuum Coelestium ab anno vulgaris aerae MDCXVII. Joannis Kepleri Astronomi Opera Omnia*; Edidit Dr. Ch. Frisch. Francofurti A.M. 1859, **2**, 775.

[†] I am indebted to my friend Dr. H. L. Crosby of the University of Pennsylvania for the translation of this extract from the *Narratio*. The text that has been followed is that given in Berthold's monograph.

reliability of the observation, because a break in the clouds disclosed the rising sun to me, so that I thought that the clouds flying past gave the false impression of a spot on the sun. The observation was repeated perhaps ten times with Batavian telescopes of different sizes, until at last I was satisfied that the spot was not caused by the interposition of clouds. However, not willing to believe in the manifest testimony of my own eyes, on account of the strange and unsual appearance of the sun, I immediately called my father, at whose house I was then staying having returned from Batavia, in order that he might be present also to observe this, though not without fearing damage to his eyes. Having adjusted the telescope, we allowed the sun's rays to enter it, at first from the edge only, gradually approaching the center, until our eyes were accustomed to the force of the rays and we could observe the whole body of the sun. We then saw more distinctly and surely the things that I have described. Meanwhile clouds interfered, also the sun hastening to the meridian destroyed our hopes of longer observations; for indeed it was to be feared that an indiscreet examination of a lower sun [less altitude] would cause great injury to the eyes, for even the weaker rays of the setting or rising sun often inflame the eye with a strange redness, which may last for two days, not without affecting the appearance of objects. Therefore I warn observers that if they wish to observe these things they should use caution, lest by the sudden influx of light they should endanger their eyes; but adjusting the telescope as is fitting, let them begin with a ray of light from the smallest portion of the sun, until the light from the whole sun can be borne at once. But every one to his own taste and convenience; it was enough for us on that momentous occasion to have learned such caution through necessity. Thus that first day passed, and we left the sun, but not without great longing for its return on the morrow, so that our natural curiosity scarcely bore even the intervention of the night. Nevertheless we restrained our eagerness by anxious thoughts. For it was not yet certain whether that spot which we had seen would wait for the next observation, which made us the more impatient the more uncertain we were in so great a matter. However, after having discussed the matter this way and that, each of us viewed the outcome according to his nature and desires. I, at all events preferred to doubt, rather than forthwith to form an opinion on the dubious testimony of a matter of uncertainty, which would have to be abandoned not without shame if the matter should turn out differently. Nevertheless I proposed to myself two alternatives, one of which must be withdrawn from consideration. For the spot either was on the sun, or was exterior to the sun. If on the sun there was no doubt but that it would be seen by us again, but if exterior to the sun it was impossible that it should be detected on the disk of the sun on successive days. For through its own motion, the sun would have moved away from this little cloud or body suspended between us and the sun. That night passed in doubting rather than in sleep; when we were aroused by the return of the sun which with its serene countenance rendered a welcome decision for us in that doubtful affair. Running, hardly bearing the delay of my curiosity to see the sun, I observed it. At the first glance of my eye the spot immediately appeared again, affecting me with no small pleasure. Since although my doubt of the night before had prepared an alternative solution, by either of which we should learn the truth of the matter, still by some intuition I had secretly chosen this one. And thus as it passed, we spent this day with frequent glances at the sun, scarcely satisfying our desires for observing, although our eyes with difficulty endured our persistence, which they protested against by threatening some great danger. Meanwhile we were so far from removing all doubts by frequent observations, that we became aware of even greater difficulties, because this spot from the begining of the first inspection up to the last observation seemed to have moved from its position, which, while it was at that time almost imperceptible, was sufficiently great to arouse a doubt in our minds. Not wishing to tire our eyes any more with that labor, we took council in order that if by any suitable means we could relieve them on the next day, we might by no means neglect it.

We planned therefore to admit the rays of the sun through a small aperture and to observe them in a dark room with a window closed. For it is known from optics that everything that exists or happens outdoors can be represented in a dark room with only a small aperture, through which the appearance of things as cast in front of the aperture itself gain entrance, so that they strike the opposite wall of the room, but with everything inverted*. Therefore planning to contend with the difficulty of the problem by this device, we admitted an image of the sun into the dark room, and as it entered, at a convenient distance from the aperture† we received the image upon a paper, which we moved continuously lest perhaps the spots on the paper be mistaken for spots on the sun. We noticed at once a rather large spot, like a longish cloud, sensibly fainter toward one extremity. For this is the way it appeared to us in the dark room and through the telescope. This place where the first observation was made we reserved for ourselves, both for repeating the observations and for observing differences if any should occur. But after the sky had permitted these observations, unexpected as it were, by favoring us with almost continuously good weather, it did not allow observations for more than three days, because of continued obscurity intervening.

Finally the sky again cleared, dispelling the clouds, and permitted a view of itself worthy of everlasting memory. We saw the spot in the sun, moved from east toward the west, but in an oblique direction; and as we looked more carefully we saw another spot near the edge of the sun's disk, but smaller, which nevertheless following the larger one after an interval of a few days had reached almost the center of the sun's disk. To these was added another, so that now three could be seen; one of which, the largest, gradually reached the other edge and vanished from our sight; the rest planning the same thing very soon, as could clearly be seen from their movement, and in the course of a few days they too vanished. Assuredly my mind was in great doubt, it hoped, it feared, so that I could have almost bidden the spots farewell as if never to return, had not my hope suggested by a suspicious inward feeling, aroused me not in vain to the expectation of a future return. I therefore awaited the course of events for about ten days; while I was doing this, once more in the neighborhood of the eastern edge, the large spot which not long ago had first disappeared, commenced to appear. When, progressing noticeably, this had worked its way further into the disk of the sun, the rest followed, with a rather obscure indication of themselves as is likely to occur near the edge. Then indeed, I perceived that they took part in a sort of revolution; for they presented themselves to view on our side of the sun, and then by their own motion progressed so that they finally hid themselves in the part turned away from us and were not seen, but shortly to become visible again. However, I was not able, nor did I wish to persuade myself of this by a single revolution, lest I should deceive myself and others, but by several consecutive revolutions, which from the beginning of this year up to the present time, not I alone had noted but others with me, in order to gain credence in this matter, and to persuade those who will by chance think that this matter of observation will be troublesome or tedious for them. But I must not neglect to mention the doubt that began to disturb me after some observations had already been made, to such an extent that I not only put off the field of writing, which in the beginning I had undertaken knowingly, but even began to regret the time spent in making these observations. For I saw that the spots did not always maintain their exact distances from each other, nor were they carried across the disk of the sun with the same velocity, but in the middle more quickly, more slowly near the edge; while the spots generally lost at the edge that appearance which they had in the middle of the disk. The cause of this thing, however, although it was easy to discover, still was able to escape my attention, not yet investigating carefully; but finally with more careful investigation I found clear proof from necessity, so that what at first seemed to hinder my undertaking, not only did not hinder it, but proved to be of the greatest assistance in demonstrating its truth. For since from the observation it is probable that the spots adhere to the body of the sun, inasmuch as the sphere is round and solid they cannot have the same motion nor relative shape and distance. For in the middle of the disk the spots move in a line parallel (sic) as it were to the line of vision, but when they are about to pass off the edge the spots move in lines oblique to the vision, and thus many parts of vision coalesce into a line that is more oblique, hence the motion appears slower. The same must be judged with regard to the different shape and distance of the same spots, for that which in the middle (of the disk) was elongated, when moved perceptibly further can acquire a round shape, the intervening distance at the same time being shortened. For a straight line so placed as to coincide with the line of vision represents a point, for the many points coalesce into one line of sight. Hence, therefore it is manifest, that it could not be otherwise if the spots move around the sun, however much my first notion, before I had thought of the idea of rotundity, persuaded me to the contrary. At this point, therefore, we invite those who do not refuse to strive for truth and nature, to perfect this material which we present here crudely, and by a united defence to relieve the weakness of our solitary position against an almost incredible multitude of those that bid fair to oppose us; not indeed because we fear those who, indifferent to the tedium of observing, if there be any, themselves intend to investigate this matter (for they will hardly deny the evidence of their own eyes out of respect for anybody else). But because we fear greatly the unjust censure of those who, without employing the evidence of their own senses, straightway fly to uncivil contradictions and cause our industry, whatever it may be, to be suspected by the more ignorant. But that cannot hinder us greatly if we only succeed in making some to understand. I do not envy them their heads, if they do not envy us our eyes with which we have assured ourselves of these things. For the thing is worthy of obser-

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* The principle of the 'camera obscura' had previonsly been employed by David Fabricius when observing the eclipse of 1590 (*Astronomische Nachrichten* **31**, 129).

† Regarding this aperture, a note by Berthold (*Op. Cit.* p. 24) is of interest. "At the parsonage at Osteel, there is still preserved a metal plate, which according to tradition may be the blade of the turf-spade with which David Fabricius was killed" (by an enraged parishoner). "On examination Häpke found that this was a copper plate pierced with a small hole, bearing the inscription '1612 DAVID FABRICIUS PASTOR TO OSTEEL', and which may have been employed for the first solar observations."

There is no statement or other evidence that would lead one to believe that the two Fabricii were acquainted with the method of observing by projection with a telescope. Nor is there any reason for believing that colored glasses were used by them to temper the sun's intense light. This is worthy of note, for colored glasses, which seem to have been introduced by Peter Apian about 1540, had previously been used by David in 1590; for he remarks in the *Calendarium Historicum* that he had observed the solar eclipse of July 21, "per duplex diversi coloris vitrum." (*Astronomische Nachrichten* **31**, 135).

> vation and should be considered by all students of nature. At all events, I have made my contribution, let others offer theirs. I have thought it sufficient to have given a narrative demonstration, and to have invited others to make further investigations. Here, some, however, if they are permitted to reflect, will suspect a revolution of the solar body in its place, which was asserted by Jordanus Bruno, and which Keppler has recently energetically defended in the commentaries which he has published on the motion of Mars: Keppler, a man of profound learning and admirable judgement, than whom not only in divine learning, but also in natural science I hardly know a better man in our age. But what we should make of the spots I do not know. If, however, we do not place them on the sun itself, are they clouds? I will not believe that anyone here will rashly depart from antiquity, which has otherwise carefully enough forbidden the clouds from passing back and forth from the sun to the sky, and has prevented with an impenetrable void the familiarity of our nature with the sky. For we shall not think with certain of the ancients, that the sun is in such want that it nourishes itself from our region or any other, unless under the name of fire it makes itself liable to such a charge of voracity that through the inborn greed with which it seizes everything for itself it does not spare even our abode. But a student of nature must think differently; if indeed these spots have been seen by many people and are several centuries old, it may be that many have been deceived in mistaking them for other celestial bodies, for which indeed they ought to be pardoned because of the rarity of the observation. Nor do I think that we ought rashly to agree with the one who, through a desire to relieve our doubt, placed the workshop for comets in the sun, from whence emissaries and spies, as it were, are sent out shortly to return again to the sun. But, if they will pardon the expression, let them not spy upon our ignorance in this direction. For I consider this portion of nature to be one of those things, which, exposing the feebleness of our intellect, invites us to more cautious thinking than that which the imagination or overshrewd reasoning from the trivial would induce. I indeed, at this point prefer to keep cautious silence rather then prate about these things rashly; meanwhile let us not make the mistake of destroying this phenomenon of nature by private doubts and considerations. In truth, if anyone having obtained from the sun permission to speak shall persuade himself of its revolution, he will not contend against me, nor will he be opposed to others, because a good many not only do not deny it, but even uphold it by arguments which are not rashly to be contradicted.

The date of dedication of the *Narratio* is June 13, 1611, (Idib. Iunii). Its appearance from the hands of the publisher was in the fall of that year. To be more exact,—at the time of the Fall Fair or "Herbstmesse" of the year 1611. We are assured of this by a letter from David Fabricius to Michael Maestlin, dated December 1, 1611, in which he writes:*

> My son published a tract concerning those things [the spots] at Wittemberg, where he is studying medicine, at the time of the last Fair.

This is further confirmed by Kepler in a long letter to Wackher, the Counsellor of the Emperor of Austria, unfortunately undated but most probably written early in 1612, in which he writes:†

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* *Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich*, **3**, 144, 1858.

† *Kepleri Opera Omnia*, **2**, 776.

> Finally then we must believe that the promise of Jo. Fabricius was not in vain, who at the last Fair in the index of the Catalogue promised us sun spots. Oh, we slow people of Prague! Who, although we have Leipsig as a neighbor, have not even yet seen a copy of this book.

The final confirmation is in the Catalogue itself, the *Frankfurter Messcatalogue* contains the announcement; "Joh. Fabricii Phrysii de maculis in Sole observatis et apparente earum cum Sole conversione Narratio. 4. Wittebergae 1611."*

Our interest naturally centers in the question, on what date did Johann Fabricius first see the spots on the sun? The *Narratio* itself gives no information on this point further than an indefinite statement that observations had been made since the beginning of the year. The correspondence between David Fabricius and Kepler had been discontinued in 1608. The *Prognosticon Astrologicum* of David Fabricius for the year 1618, which mentions the death of Johann, may have contained information, but all copies of the book are lost. *The Calendarium Historicum*† yields no information as Olbers regretfully informs us‡. Thus, until recently all endeavors to fix this date have been largely conjectural, based on the indefinite statement in the *Narratio*; hence various authorities, without citing any documentary evidence and for reasons best known to themselves, have placed the date anywhere from July 1610 to December of the same year. But with the recovery of the *Prognosticon Astrologicum* for the year 1615¶ (now in the Imperial Library at Vienna), it is possible to state definitely the exact day upon which the first observations were made. Johann Fabricius first saw the sun-spots on the 27th day of February 1611, O. S. (9th of March, N. S.). In the *Prognosticon* David writes: ||

> So muss ich auch allhie von etlichen andern Meteoris und Apparentiis etwas meldung thun sonderlich dass man jetziger zeit in der Sonnen maculas oder schwarze bloitlein eygentlich gespürt und wargenommen wie dann solches neben mir von meinem Filio M. Johanne Fabricio Medicinae studioso im Jar 1611. den 27. Febru. styl. vet. durch die Holländische Brill am allerersten ist observirt worden davon auch für aussgang dess Jars zu Wittenberg einen Tractatum latinum in 4. hat lassen ausgehen. Es hat aber diese Speculation hernach Apelles Anonimus herrlich erweittert unnd gentzlich geschlossen, das die Lufft mit solchen corpusculis tenebrosis erfüllet sey weil fast täglich unter der Sonnen solche maculae in alia atq: alia forma herlauffen unnd gesehen werden. Was es eygentlich sey und zu welchem end solches von GOTT erschaffen ist schwerlich zu ergründen.

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* Berthold, *Op. Cit.* p. 14.

† *Calendarium Historicum earem Rerum, quae ministerii mei tempore in Europe inde contigerunt*......Davide Fabricio Eseni pastore Resterhavensi collectum. Anno 1590, et seq.

‡ *Astronomische Nachrichten*, **31**, 129.

¶ *Prognosticon Astrologicum auff das Jahr nach der Gnadenreichen Geburt unsers Herrn und Heylandes Jesu Christi, MDCXV*......Gedruckt und verlegt zu Nürmberg durch Johann Lauern.

|| Berthold, *Op. Cit.* p. 13.

The sun, the Eye of the World,—afflicted with spots! We have seen the extraordinary interest and excitement aroused by the publication of the *Siderius Nuncius* of Galileo, and one imagines the excitement that must have followed the appearance of the *Narratio*. How the author was lauded, or condemned from all sides. But alas, such was not the case. It is most extraordinary that the pamphlet attracted so little attention, and that all traces of it and of its author should have so quickly disappeared. In vain one examines the literature of the day and the correspondence of his contemporaries. Except in the writings of Kepler, Maestlin and Mayr, the name of Johann Fabricius is not found. During the hundred years after the appearance of the *Narratio* we find it mentioned in only a single publication.*

In explaining this peculiar state of affairs, we are not warranted in assuming that we are concerned with the overlooking of an insignificant pamphlet, the author of which was entirely unknown. The Book Catalogue of the Fair reached the hands of the learned men of the day, and the title of the *Narratio* must have been sufficiently novel to have attracted their attention. We must look further for the reason. Kepler in the above mentioned letter to Wackher, laments that he has not yet seen a copy, but in a postscript, however, he indicates that he has come into posession of one since the letter was written: †

> Indeed at a most opportune time for you, even now is Fabricius testifying with regard to the solar spots. You will see that the agreement is not to be despised, if you survive the tedium of reading round-about vacancies of words.

But the body of this long letter is concerned with Apelles' letters to Welser which Wackher had forwarded to him, and which had caused him a sleepless night. He remarks of Apelles:

> Whoever he is, he talks like a mathematician, he reasons soberly, he seems to have guarded himself well.

Kepler analyses the three letters most minutely, discusses the observations, and submits the hypotheses to a searching test.

From this we learn that even before the *Narratio* had become widely circulated it was overwhelmed by a dangerous rival. The Jesuit Scheiner had found an invaluable patron in the person of Mark Welser, who not only had the Apelles' letters printed, but gave them wide circulation. But another, more formidable than Scheiner appeared on the field announcing the discovery. This was of course Galileo who, as we have seen, had shortly before astonished the world with his *Sidereus Nuncius*, announcing new wonders in the heavens discovered with his telescope. If one examines the writings of Scheiner and Galileo, and compares them with the *Narratio* of Fabricius, one will then readily comprehend why the school-boyish work of Fabricius should have been indifferently pushed aside, while the maturer writings of Galileo and Scheiner were eagerly read.

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* Jo. Wolfgangi Rentschii, *Disputatio de maculis et faculis Solaribus.* Wittenbergae 1661.

† *Kepleri Opera Omnia,* 2, 782.

To the inherent weakness of the *Narratio* in this respect, and the wide circulation of the writings of Scheiner and Galileo, there is to be added another fact which may assist in explaining why the *Narratio* and its author so swiftly passed into oblivion. The clue to this is given by Simon Mayr, who bemoans that Scheiner had denounced him for a 'Calvinist', which he certainly was not; and then legitimately inquires what astronomy has to do with religion, adding:*

> The first discoverers and observers of the solar spots are the two Fabricii, father and son; but since they are considered heretics their names are suppressed.

One may be disposed to attribute such reasons to prejudice, but aside from this there still remain grounds for suspicion. It was but natural that the mighty organization founded by Loyola, now that one of its members had at an early date observed the solar spots, should henceforth bring its whole power to bear in the effort to retain for him the credit of the discovery. That this was only too true, the reader will learn in a later portion of the present discussion.

(*To be continued.*)

CELESTIAL MOTIONS IN THE LINE OF SIGHT.

[*Additional Note.*]

RUSSELL SULLIVAN.

In regard to a criticism of my article, "Celestial Motions in the Line of Sight," in the February number of POPULAR ASTRONOMY page 110, I said parenthetically, "The plane of the solar system exhibits a similar tendency to move edgewise through space, towards the Sun's distant goal." The criticism states that the apex of the solar motion lies within 30°, possibly less, of the pole of the ecliptic. Campbell (*Lick Bulletin* 196) puts the solar apex at R. A. 268°.5 ±2°.0, Dec. +25°.3 ±1°.8, which places it about 41° from the pole of the ecliptic. Thus the ecliptic or plane of the solar system is inclined about 49° to the sun's way, enough to justify the statement quoted above.

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* *Mundus Jovialis, anno MDCIX. detectus ope perspicilli Belgici.* Norimbergæ, 1614. "Ad Candidem Lectorem."

JUPITER—THE SOLAR KING.

GEORGE A. RUSS.

Could the Ancient Astronomer but view the starry hosts of heaven through the gigantic telescopes of today! How astonished he would be to penetrate into millions of miles of space and bring to view the wonders of the boundless sea knowing that these objects are not, as he supposed, mere specks of light in the sky, but in reality other worlds, many of them giants compared to this little insignificant globe of ours.

And, like the ancient astronomer, many of us do not realize what wondrous things are those brilliant lights we see shining above us. For instance, take the planet Jupiter, what appears to us as a small speck of light is really one of the greatest wonders of the heavens. Its light is only inferior to that of the Sun and is so brilliant that it casts a shadow. This wonderful body is 483,000,000 miles, or over five times as far from the Sun as the earth is and its orbit is of such magnitude that its year is almost twelve of ours. Its rotary motion is so rapid that it is flattened at the poles and bulged at the equator and if it were to rotate just a trifle faster it could not keep itself together, but would burst, and be spread broadcast on the skies like so much paint. The rapidity of its rotation is better understood when it is known that its year contains 10,455 days.

But as wonderful as these things are they lack interest when the great size of Jupiter is taken into consideration. This monster of the heavens has a diameter of 88,000 miles, a circumference of 264,000 miles and a surface area of 23,232,000,000 square miles or 121 times that of the earth; while its volume is 1390 times and its mass 300 times that of our globe. In size it is second only to the Sun, and easily dwarfs all the other planets put together; for were the whole of them combined in one mass, that mass would not weigh half as much as this colossal planet and if it were cut up into 1,300 pieces, each piece would be larger than the Earth.

Everything connected with Jupiter is so colossal that our utmost efforts fail to grasp a definite idea of the immense scale on which it is constructed. It is next to impossible to form an adequate idea of its great size by the use of figures as used in the science of Astronomy. To grasp an idea of the dimensions of this huge planet we must compare it with something with which we are more or less familiar. To this end what will serve our purpose better than to increase, as it were, the size of our earth to that of Jupiter, for who is not familiar with the geography of our globe?

First, we find that the total area of our earth would be 23,232,000,000 square miles. Of this vast area 17,119,800,000 square miles would be occupied by the seas and oceans, leaving 6,292,000,000 square miles to be distributed among the continents, islands, etc.

The Pacific Ocean, the largest body of water on the globe, would cover an area of 6,734,860,000 square miles and The Challenger Deep, near the island of Gaum, the deepest depression of the Earth's surface, would be 316,000 feet deep while The Aldrich Deep, near New Zealand, would be 309,500 feet deep and the Tuscarrora Deep, east of Japan, would extend for 279,300 feet below the surface of the Pacific. A journey from San Francisco to Yokohama, Japan, would require a trip of 52,800 miles and the fastest ocean liners would be considerably over three months in completing the voyage.

Asia, the largest continent, would stretch out over 2,029,291,000 square miles of territory and the distance across this huge tract of land, from the Mediterranean Sea to Bering Strait, would be over 60,000 miles. Its coast line would be almost 355,000 miles in length and if straightened out in a direct line would extend to the moon with 116,000 miles to spare.

China would have no fears of territorial aggression from Japan, as the little "Island Empire" would now be 19,602,000 square miles in extent and there would be ample room for all the Japanese for hundreds of years to come. We find the Chinese Empire with an area of 512,435,000 square miles, while India would contribute 188,760,000 square miles to the 1,347,698,000 square miles that would go to make up the Empire of "John Bull."

Mt. Everest, the highest peak in Asia and the highest known point on the globe would loom up a massive Sentinel, 319,000 feet in height, while many other summits of the Himalayas would exceed an altitude of over 60 miles.

Africa with an area of 1,392,589,000 square miles would be an interesting study indeed. We would find here some of the greatest rivers in the world, such as the Kongo, 31,900, the Niger, 28,600, Zambezi, 15,000 and the Nile, 37,900 miles in length. Here we would find the great Desert of Sahara, a barren waste of sand and rock, 242,000,000 miles in extent, while 14,000 miles to the South is Lake Victoria Nyanza, 3,218,600 square miles in area, and next to Lake Superior the largest body of Fresh Water on the globe.

Although the Islands of the world would not offer us such comparisons as the continents, we may be interested to know that Borneo, the world's largest Island, would have an area larger than Asia, Africa and North America combined, while Cuba would be a larger country than the United States, Mexico, Germany, Italy, France, Spain, Japan, Norway and Chile combined.

What a large, undeveloped body of land South America would be! Stretching a distance of 47,000 miles from Lake Maricabo to Cape Horn. Here we would find the lofty Andes, rising from the very sea-coast, and extending the entire length of the continent with many of its Peaks such as Aconcagua, 238,690 feet; Sorata, 232,810 feet; Illimani, 211,500 feet; Sahama, 209,700; and Chimborazo, 206,960 feet in height piercing the sky in all directions.

The largest river in the world, the mighty Amazon, rising in these mountains, would have a course 38,000 miles in length, with a drainage area of 302,500,000 square miles. Its width where it empties into the Atlantic would be over 2,000 miles and the volume of water it discharges would be so great that the waters of the Ocean would be freshened 500 miles from shore.

The great frozen land of the Midnight Sun would indeed be a barrier to all mankind and no Polar expedition would ever be attempted amid the ice and snow as is now done. Greenland, that barren waste of ice and snow—the most absolute desert known in the world—would be 60,500,000 square miles in extent and throughout this vast area, excepting a short strip near the coast, there would be no living thing and in the interior where the elevation would be 100,000 feet, the temperature, even in midsummer, remains, as now, below zero, and rain would never fall. The Great Muir Glacier of Alaska would rise 2,000 feet above the water, and extend 8,000 feet below, presenting a vast expanse of ice 700 miles long by 250 miles wide.

Our own country would be a country of "Magnificent Distances" and would, as now, contain some of the greatest natural wonders of the earth. A man travelling from New York to Chicago would grow weary of his 10,000 mile ride, while the 2,057 mile trip between Chicago and Rock Island would be quite an undertaking. Evanston would be located on an inland sea of 2,629,330 square miles and would be 123 miles north of Chicago, while Milwaukee would be 850 miles away.

The Rocky Mountains would be 57,000 miles in length and 37 of its peaks in Colorado alone would be more than 140,000 feet above sea-level, while the lava deposits in our Western States would cover an area of 18,150,000 square miles.

The wonderful Yosemite Falls, which are famed the world over, would in one mighty leap, make a descent of almost three miles.

The Mississippi-Missouri River with a length of 47,300 miles would drain 152,460,000 square miles of territory and each year enough sediment would be poured from its mouth into the Gulf of Mexico to build a pyramid 121 miles square at the base and 3,000 feet high.

As so many objects on this earth offer themselves for comparison, we could go on with our illustrations indefinitely, but enough has been said to give a fairly clear idea of the tremendous mass of matter contained in the greatest planet of the Solar System—Jupiter.

Rockford, Illinois.

ORIGIN OF METEORS.

COL. W. F. BADGLEY.

The conclusions arrived at regarding meteors and their origin appear to be: (1) that they are not of the same class as falling stars; (2) that they are similar in structure to some of our minerals; (3) that they are fragments of a burst world or satellite. The first and second of these statements can be accepted without any doubt, but the third is questionable, for, with the exception of comets, there has never been observed a phenomenon indicating the disruption and scattering of the material of any celestial body belonging to our system, while any such occurrence outside it would not affect us at all. There are besides many signs that induce a belief that when condensation and construction of material have begun, there is no subsequent destruction or dispersion, because among the thousands of nebulae that have been discovered, the greater number have a marked appearance of condensation, and none show any sign of segregation.

The spot on Jupiter, which is supposed to be a moon in process of formation, might be cited as an example of segregation; but if it were being projected from Jupiter, it would circle round faster than the planet, instead of which it goes slower; and besides the spot is less distinct now than it was formerly. It seems therefore more likely that if it is a moon, it is a moon that is being absorbed by Jupiter.

The small planets that form a ring between Mars and Jupiter must have preserved their orbits for ages; they are not the scattered debris of a shattered world flying apart, but the original parts of a world that have failed to unite. It is generally believed that our moon was thrown off by the earth, but that is quite impossible. Since its inception the world has been acted upon by two forces: the centripetal force of gravitation, and the centrifugal force of gyration. The first has constantly increased in concentrated strength, and the other as constantly decreased; and had it been otherwise, our universe could never have come into existence. The contest between the forces has been increasing, with no bursts of vigor or lapses to weakness, but an absolute steady continuance, and no body so acted on by such forces could possibly divide itself. The earth could not have thrown off the moon which has always been a separate body. It should have been part of the earth but failed to join from some cause or other.

Gravitation makes itself felt everywhere from solid material, and it strengthens rapidly with approach. Therefore the suns, planets, and moons, have concentrated in themselves a centripetal force, increasing with their ages, which, from the first must have prevented them from breaking up; and if there were any outside force capable of breaking them—and there is none such known—their fragments could not separate because mutual gravitation would hold them together with an attraction thousands of times stronger than any attraction from without.

All these considerations furnish us with indisputable evidence that meteors cannot be the debris of a shattered moon or planet, and the only conclusion that we can come to is that they are bodies that originally ought to have been part of our globe with which they failed to combine. We may say that they are tiny satellites which circulate between us and the moon. They are not pieces provided by a ruptured world, but part of the material dispersed in the primitive cataclysm that originated the nebula that gave origin to our sun and its planets.

The shooting stars, although they are the scattered dust of the same original nebula—dust that should have joined the sun or planets—are not among our minuscule satellites, but come from trails of the old nebula, of which what is called the zodiacal light is the principal remainder. In these trails there are left only small stones as the larger ones have been absorbed, and the small size of these stones causes them to be entirely burnt up before ever they can reach our globe.

Devizes, England.

WINTER'S GLORIOUS GALAXY.

CHARLES NEVERS HOLMES.

The Dog-star glitters!—Rigel sparkles white
    And Queen Capella crowns the skies of night,
Like ruddy eye Aldebaran's fires blaze,
    And Pleiades amid a shining haze;
Once more lone Procyon adorns our sky
    And side by side the twinkling star-twins lie,
As Betelgeuse beams like a beacon's light
    And, set with suns, Orion sparkles bright.

Our northern world is sleeping once more under its spotless covering of snow. A cold, white storm has come, and gone. The bare, frozen ground of hill and vale is shrouded with a new mantle, just fallen upon it. As yet, this recent snow is almost wholly untrodden; its soft, upper crust has never been warmed by the Sun or lighted by the Moon's silvery rays. It is nine o'clock in the evening; the month of January draws nearer and nearer to February. Moonless night's darkened dome extends like a vast supernal bowl above a dim, white world—a darkened dome a-blaze, as it were, with myriads of sparkling stars. The evening air is cold, yet healthful; and it is so clear that the myriads of scintillating suns seem to be nearer than usual, glittering indeed like sidereal gems and glowing at times like titanic sky-furnaces.

Stars and stars, myriads and myriads of them—the whole heavens fairly on fire with their sparkling splendor! Yet, nevertheless, in one section of our firmament, these suns of night are far more conspicuous than elsewhere. In the south, extending from horizon to zenith, there glitters a remarkable group of these sky diamonds, with their associated constellations. There are six of these sky-jewels, each being of first magnitude. There are four starry constellations, each of which is noticeable. Taken altogether, this remarkable group of sky diamonds and constellations is by far the grandest and greatest to be seen in our northern latitudes, and, viewed under favorable conditions of a clear, moonless firmament, this brilliant assemblage of suns is indeed sidereally spectacular.

Queen Capella, bright and beautiful, reigns near the zenith, crowning a constellation of six easily seen stars which lie, most of them, close to the borders of the dim Milky Way. Somewhat lower down, southwestwardly, there glitters the constellation of Taurus—five chief stars—one of which is particularly bright, ruddy and glowing in appearance, Aldebaran, the so-called "eye of the Bull." There is another, more famous sky-feature of Taurus, the tiny, beautiful cluster of Pleiades, at the western end of this constellation. And southwardly, below Taurus and its ruddy gem Aldebaran, there sparkle and scintillate the suns of Orion, a very well-known, beautiful constellation.

Orion—glorious Orion! Long before the New Year, even before the first day of December warned us of winter's frost and snow, we saw him rising slowly, higher and higher, above the southeastern horizon. Flickering Betelgeux came first in sight, then the three "belt-stars," and finally brilliant Rigel glittered in our view like some celestial diamond of flawless water. Once more this grand, old-time constellation sparkled like some bright and beautiful piece of firmamental jewelry, hanging resplendent against the darkened background of night. Majestic, remote!—glorious Orion, gleaming, shining, when evening's sky is clear and cold, and our northern hills and vales are covered with a soft, white mantle.

Eastward of Taurus and Orion, there is seen the inconspicuous constellations of Gemini and Canis Minor. In Gemini, composed of nine chief stars, a sort of irregular rectangle, we find those famous twin-suns, Castor and Pollux, twinkling to the north-eastward. In Canis Minor, there are only two stars easily visible, one of these being of first magnitude, named Procyon. Procyon is situated firmamentally all by itself, below Gemini. It is not particularly a conspicuous first magnitude sun; but this could hardly be expected amid such a sidereal galaxy. The dim sky-river of the Milky Way separates winter's glorious galaxy, firmamentally; Gemini and Canis Minor being upon the eastern side of this dim sky-stream, Taurus and Orion upon the western side. Still further eastward, at some distance in the starry dome from Procyon of Canis Minor, there is sparkling a bright sun, called Regulus, at the bottom of a sickle-shaped outline. Although this bright star is not a part of winter's glorious galaxy, so-called, it is well worth our while to look eastwardly for bright Regulus and the remarkable "Sickle" of the constellation Leo.

And last, most magnificent of all suns of night, there sparkles and scintillates the incomparable sky-diamond Sirius. There does not seem to be any need to describe this splendid sun's firmamental position. He glitters below both Orion and Canis Minor. The three "belt-stars" of Orion pointing downward in his direction, somewhat like the three stars in the handle of the Dipper, indicate the sky-position of that second brightest sun of our northern latitudes, Arcturus of Boötes. But although Arcturus, in his season, is a great sun of night, he is hardly a brilliant firmamental gem compared with Sirius of Canis Major. Just as Queen Capella crowns her constellation Auriga, so King Sirius is a diamond-diadem at the apex of his constellation Canis Major. So much superior is he to the other stars of the Glorious Galaxy, that they look rather disappointing to us after we have admired Sirius for a while. King Sirius is, of course, no zenith sun like Queen Capella; but, as we see him for the first time in winter, on some cold, clear, moonless evening, we are almost spellbound by his spectacular appearance. He sparkles and glitters like a veritable diamond of fire, and it seems sometimes difficult to believe that this most magnificent of suns is scintillating and shining trillions of miles distant from us.

Our northern world is sleeping once more under its spotless covering of snow. A cold, white storm has come, and gone. The bare, frozen ground of hill and vale is shrouded with a new mantle, just fallen upon it. It is nine o'clock in the evening; a moonless, cloudless darkened dome extends like a vast supernal bowl above a dim, white world. But the suns of night are shining gloriously upon us: Queen Capella sparkles near the zenith, ruddy Aldebaran glows like an angry eye, Betelgeux and Rigel adorn Orion, Procyon sparkles like a sky-gem—alone, and Sirius, incomparable King Sirius, scintillates with all his majestic splendor. Winter's Glorious Galaxy!—like some stupendous sidereal picture, hanging upon the star-lighted wall of an eternal, illimitable Universe!

Boston, Mass.

THE DOG-STAR, SIRIUS.

Supreme supernal, sparkling and sublime.
Undimmed through ages of eternal time,
Remote, yet near, resplendent like a gem
In Canis Major's starry diadem;
When winter's snow lies deep on fell and fen,
When hearthstone's blaze warms homes and hearts of men
In southern sky—O grand celestial sight!—
The Dog-Star reigns o'er shining suns of night.

Charles Nevers Holmes

Newton, Mass.
41 Arlington st.

From the Herald's Astronomer.

TRANSITS OF MERCURY AND VENUS.

WILLIAM HALLER CASSELL.

Transits of the inferior planets, Mercury and Venus, across the disc of the sun at inferior conjunction are interesting celestial phenomena. From a physical standpoint, a transit of one of these planets is analagous to an eclipse of the sun—the only difference being that the planet is so small in comparison with the sun that the cone of shade formed by the planet falls far short of the surface of the earth. The consequence is that an observer on the earth would never detect that a transit was taking place if he had not previously informed himself. The fact of the matter is, a transit is an *annular eclipse* of the sun by the planet.

Usually at the time of inferior conjunction, *i. e.* when the planet passes between the earth and sun, its position in its orbit is such that it passes either to the north or south of the sun's disc. This, however, is not always the case. The inclination of the orbit of Mercury to the ecliptic is 7° 00′ 08″ and if the conjunction occurs when the planet is very near its node, it will pass across the disc of the sun from east to west, and through the telescope will appear as a small black dot on the sun's brilliant surface. It is, however, too small to be seen with the naked eye as Venus can be under similar circumstances.

A transit of the sun by a planet affords one of the best opportunities for measuring the diameter of the planet, but unless the utmost care is taken a diameter so obtained is apt to be too small on account of irradiation or *glare* of the sun's brilliant background.

The nodes of a planet's orbit are the points on the celestial sphere where it crosses the ecliptic, and in the case of the planet Mercury, its nodes are in longitude 227° and 47°. These points are passed by the earth on May 7 and November 9 respectively. The consequence is that transits of the sun by this planet can occur only on or near those dates. The "transit limit" of a planet, corresponding to the "ecliptic limit" of the sun and moon, is affected by the ellipticity of the orbit, and the distance of the planet from the earth and sun. If the orbit of Mercury were strictly circular its "transit limit" would be only 2° 10′, but, since the orbit is decidedly elliptical, its transit limit is increased. At the time of the May transits Mercury is near its aphelion, or point farthest from the sun, and if an inferior conjunction should occur at this time the planet is at its closest possible approach to the earth. This diminishes the May limit, but the November limit is correspondingly increased. As a matter of fact the May transits are less than half as numerous as the November transits.

With regard to the interval between transits, it is important to observe that in the case of the planet Mercury, twenty-two synodic periods are very nearly equal to seven years; forty-one synodic periods are more nearly equal to thirteen years; and 145 synodic periods are almost exactly equal to 46 years. The consequence is that after a November transit a second one is possible in seven years, probable in thirteen years, and a practical certainty in 46 years. In regard to the May transits, a repetition is not possible after the lapse of seven years, and it often fails in thirteen years.

The first transit of Mercury that was ever observed was by Pierre Gassendi (1592-1655), the celebrated French philosopher, on November 7, 1631. The last transit occurred, 1914 November 6, and was partially visible in the United States.

The following is a list of the transits of Mercury that have occurred or will occur during the twentieth century:

† 1907 Nov. 14
† 1914 Nov. 6
1924 May 7
1927 Nov. 8
1937 May 10
1940 Nov. 12
* 1953 Nov. 13
* 1960 Nov. 6
† 1970 May 9
† 1973 Nov. 9
1986 Nov. 12
1999 Nov. 14

From an astronomical standpoint, transits of Mercury are of no particular importance on account of the nearness of the planet to the sun, except in accurately determining the position of the planet.

During his life time, the late Professor Simon Newcomb, of the Johns Hopkin's University, made a laborious investigation of all the recorded transits of Mercury to ascertain the uniformity of the earth's rotation. They seemed to indicate certain small irregularities in the rotation, but hardly made the fact certain.

On the other hand, however, transits of the planet Venus are of some importance from an astronomical standpoint—they have been used and are valuable for determining the parallax of the sun. Compared with transits of Mercury they are very rare phenomena. At the time of a transit, Venus is visible even to the naked eye, as a small black dot on the disk of the sun, crossing it from east to west. The orbit of the planet is inclined to the ecliptic about 3½°, and as a consequence the *transit limit* is small, being about 4^{c}, and making transits of Venus of very rare occurrence. The sun passes the nodes of the orbit of this planet on December 7, and June 5, so that all transits must occur on or near those dates. When Venus makes a central transit of the sun's disc, the duration of the transit is very nearly eight hours.

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* Wholly visible in the United States.
† Partially visible in the United States.

Five synodic or thirteen sidereal revolutions of Venus are very nearly equal to eight years; 152 synodic or 395 sidereal revolutions are almost exactly equal to 243 years. If then, a transit occurs at any time, another is possible at the same node eight years before or after, and no other transit can occur at the same node until after the lapse of 235 or 243 years. If the planet should cross the disk of the sun centrally, the transit will not be followed by another after the lapse of an eight year period—the planet will then pass either to the north or south of the sun.

As is now the case, the transits of Venus are not central, the path of the planet being either to the north or south edge of the sun's disc, and a transit across one edge of the sun will be followed by another across the opposite edge after the lapse of eight years. If we have a pair of June transits separated by an eight year interval, they will be followed by another pair at the same node after the lapse of 243 years, and a pair of December transits will come about half way between. Transits of Venus have been coming in pairs for about 2000 years, and will continue to do so for about 1000 years from now. The following list shows the order in which transits of this planet occur:

1631 Dec. 7
1639 Dec. 4
1761 June 5
1769 June 3
1874 Dec. 9
1882 Dec. 6
2004 June 8
2012 June 6

which produces the following series: 8, 121½, 8, 105½, 8, 121½, 8, 105½ etc. The first transit of Venus that was ever observed was witnessed by a young amateur by the name of Horrox residing near Liverpool. The transit of 1769, June 3, excited great interest and King George III fitted out an expedition to Tahiti under the command of the celebrated navigator Capt. James Cook. At the same time other parties of astronomers were sent to California, Lapland, Pekin, and St. Petersburg (now Petrograd). At the transit of 1761, the French astronomer, Le Gentil, was sent out by the French Academy to the East Indies, but was prevented from making his port by high winds and the war with England until after the transit was over. Undismayed he resolved to remain abroad for the transit of 1769. Eight long years passed and the morning of 1769 June 3 dawned bright and beautiful. Le Gentil with thorough preparation to observe the event that lay nearest his heart was counting the moments when the long awaited transit was to begin; suddenly the sky began to grow black, a tropical storm arose, the first in many days, and the ill-fated astronomer again lost the opportunity to witness an event that he had patiently awaited for years.

Wytheville, Virginia.

OBSERVATIONS OF JUPITER—APPARITION OF 1914.

A. THOS. G. APPLE.

[*Continued from Vol. XXII, p. 80*].

The planet was observed from March 21, 1914 to January 26, 1915 on 80 nights, with an 11-inch refractor. The program of observations was, in the main, the same as last season: measures were taken as frequently as possible on the Red Spot, and the preceding and following ends of the South Tropical Disturbance with a view to determine their relative rates of drift. The length of the Red Spot was measured on fifteen nights. Three general measures of latitude of all the belts were made and also 100 additional measures of individual belts, each of ten settings, for correct longitude determinations of separate spots.

Satellite phenomena were noted from time to time. A number of eclipses of one satellite by another were observed, and as far as the power of the telescope made it possible, the circumstances of the eclipse were ascertained,—its magnitude, times of contact, etc.

Careful measures of position angle of the belts were made whenever possible. If the belts are assumed to be in planes perpendicular to the planet's axis, these results indicate a systematically varying difference of a small amount from the values given in Menth's Ephemeris. The cause of this difference has not been made out as yet. But there are good reasons for supposing that it is not due to errors of measurement.

The most characteristic feature on the surface of the planet has been the breaking out of a number of dark spots in the north temperate belt, each with a small white oval in its center. Thirteen of these were eventually made out. They appeared at such regular intervals as to suggest the appearance of a chain or a necklace of beads. The first appearance of these spots was noted July 21, 1914. They were usually fainter than the other markings, harder to glimpse, and disappearing under conditions of poor seeing much sooner than other features. Their regular distribution along the belt made identification difficult upon their reappearance, but a mean rotation period of

$$9^h\ 55^m\ 33^s.056$$

was made out at length by combining the results from spots number 3, 11, 12 and 13 with an average of 160 rotations of each spot. This indicates a slow eastward drift with reference to the Red Spot.

The North Tropical Belt continued to be a conspicuous object during the entire apparition. As it has become even more conspicuous during the present apparition of 1915, having broadened so as to swallow up the so-called North Temperate Belt, its behaviour during 1914 becomes an important chapter in the history of a belt whose first outbreak was detected at its very beginning in the autumn of 1912. The regular division into "bays" seen in 1913 changed very considerably during the summer of 1914. The regularity appeared broken up already in April, upon the planet's first appearance in the morning sky, and as summer advanced it became more and more irregular. Smaller ovals would appear from time to time and also smaller sub-divisions of the black spots. There seemed to be comparatively rapid changes in the spots, making it difficult to identify a given spot upon its reappearance. But by plotting the belt according to a method employed for this same belt in the fall of 1912 (POPULAR ASTRONOMY, Vol. XXI p. 15), a slope was obtained which is the mean of two of the most conspicuous spots about 220° apart, and from this was derived a rotation period of

$$9^h\ 50^m\ 18^s.74$$

though it should be stated that from spots seen in July, August, and September, 1914 a somewhat longer period is derived, viz:

$$9^h\ 51^m\ 42^s.$$

That the belt belonged to System I and had a more rapid rotation than the parts of Jupiter's surface adjoining it on the S and N is shown by the way in which the markings trail backwards in a following direction.

Along towards December the broken condition of the belt was no longer visible; it was considerably broadened and continued round the planet in an unbroken band of nearly uniform width. It is true the uncertain seeing at this time, owing to weather conditions and the planet's low position in the west counsels caution in forming conclusions; but the fact that a belt to the northward showed its two narrow close-lying members would seem to indicate that had there been spots on the other belt, they would have been seen, at least in dim outline.

During this apparition the following end of the South Tropical Disturbance passed the Red Spot. Efforts were made, but in vain, to detect the time of passage, and discover the phenomenon of the encounter. The end of the Disturbance was seen June 7 and 12, 1914 to the westward of the Red Spot in longitudes 236° and 238° respectively: It was next found August 13, in longitude 180°.6 so that the crossing must have taken place some time in the interval. This following end continued to drift until when last seen, December 17, 1914, its measured longitude was 107°.1, indicating a mean period of rotation

$$9^h\ 55^m\ 17^s.16.$$

The preceding end of the Disturbance was first seen April 9, 1914 in longitude 119°.1, and last, January 26, 1915 in longitude 24°.7 indicating a period of

$$9^h\ 55^m\ 27^s.50.$$

The disturbed area itself seemed more quiet than the preceding year, and showed fewer details. The dark material that composes it was comparatively thin, leaving a zone of white material not very much darker than the zone bounding the Disturbance on its preceding and following ends. The length of the Disturbance varied very considerably, being 136° on June 7, and only 82° on December 17. Its present length (October 1915) is 90°. This fact naturally suggests the question whether the *f* end of the disturbance could have been slowed up by its passage of the Red Spot.

The Red Spot was more clearly seen on a number of nights than we remember ever seeing it since we began our observations in 1907. It did not present any decided color, but was a shade or two darker than the zone in which it was situated, so that with very careful looking on nights of exceptional seeing its two oval ends could be made out. On the north, on such nights, a clear line of light was seen to separate it from the belt on that side, but on the south it could not be certainly differentiated from the belt there. The mean of five measures of its length during June and July was 37° 4′.7; of seven measures, August 6-November 11, 29° 7′.4. The difficulty in seeing the ends distinctly in the former period diminishes very materially the weight of the former result. These measures reduced to miles would be 52,700 and 41,400 respectively. A conspicuous feature of 1914, as it was of the year previous, was the row of white spots on the belt following the Red Spot to the north. This row bends northward as if to pass around the spot on that side. No portion of material of any kind, white or dark, has ever been seen to cross the Red Spot.

A remarkable fact noted with regard to the drift of the Red Spot was that during the early summer, while the Disturbance was still passing it, the spot drifted, and its longitude decreased from 223°.7 to 212°.5. From July 22, 1914 on its drift was first noticed to have slowed up, and from this time on it was practically stationary with respect to the zero meridian of System II. The rotation period accordingly slowed down from $9^h\ 55^m\ 34^s.24$ during the interval April 5 to June 16, to $9^h\ 55^m\ 35^s.61$ from June 16 to July 22, and then to $9^h\ 55^m\ 36^s.14$ from July 22 to November 11 when last seen. So far as our observations of the present year (1915) show, this last rotation period continues with only a slight acceleration.

It would thus seem that there is some connection between the rotation period of the Red Spot and the passage of the Disturbance, the Spot drifting more rapidly while the Disturbance is passing, a fact previously pointed out by Denning. It thus appears that the Disturbance possesses an accelerating influence and that its darkness may be due to some physical material that obscures the light from the layers below it, or fails to reflect the sunlight as strongly as the material in its neighborhood. That this must be the nature of the belts generally would be a natural inference, a theory that has been advanced by W. H. Pickering.

There was apparently no drift of the belts in latitude. The following mean values were obtained:

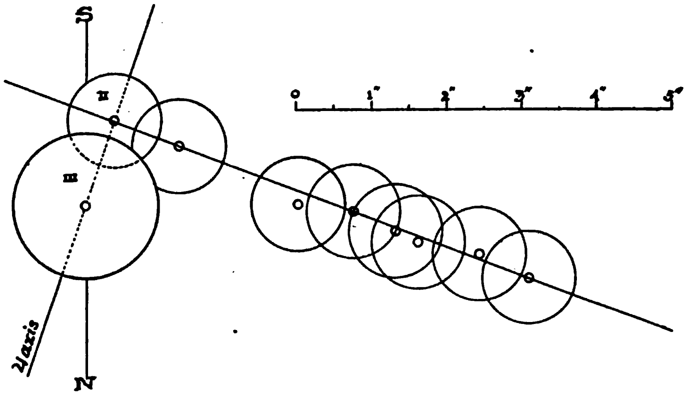
Belt	Latitude	No. of measures
NNTB	+ 35° 55'.3	1
NTB	+ 15 44.4	15
NEB	+ 6 52.5	26
SEB	— 8 34.3	1
STB	— 26 56.5	6
SSTB	— 35 46.2	3
Disturbance (*p* end)	— 20 45.2	17
" (*f* end)	— 20 4.3	6
Red Spot	— 19 30.2	20

The colors of the planet were carefully noted from time to time. The fainter tints were very elusive, the polar regions appearing at one time gray yellow, at another bluish olive. On some occasions a pinkish glow seemed to overspread the whole polar region of the N hemisphere. The southern belts, however, were always of a decided pink or brownish pink color, and also the N equatorial belt particularly on its northern border. A curious fact noted was that the pink color of the southern belts and zones extended up to the Red Spot on the preceding side and then it practically ceased for 100° or more of longitude. Advantage was taken of a visit to the Yerkes Observatory in August to test this with the 40-inch refractor. By the courtesy of Professor Frost we obtained the opportunity of a view of Jupiter. The Red Spot had just passed the Jovian meridian, and the region following lay in full view. There was not an entire absence of pink color here, but as compared with the region preceding the spot, the contrast was quite noticeable. In the southern hemisphere the red (or pink) color suggested an emanation issuing from the South Temperate Belt and overspreading the zones to the north and south, while in the northern hemisphere it was noticeable only on the north border of the North Equatorial Belt.

Position angles between the satellites and planet were measured on seven nights during May with a view to determine the time of the earth's passage of the planes of their orbits. The conclusions reached were:

May 10 — North of the orbit of satellite III
" 20 — South of orbits of II and III.

Eclipses of one satellite by another were observed July 22, August 3, and October 21, with circumstances as follows:

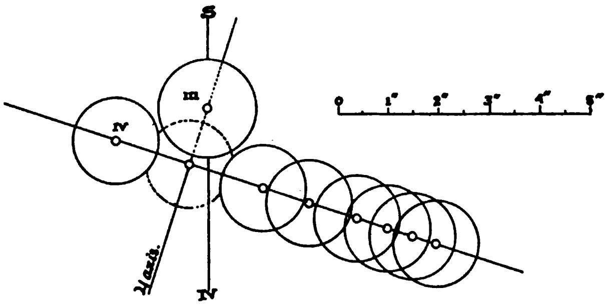


ECLIPSE OF II BY III OCT. 21, 1914, 13:14.2 G. M. T.

OBSERVED CIRCUMSTANCES OF THE ECLIPSE.

	G.M.T.		
1	13:15.2	Mid-eclipse certainly past	
2	16.7	Last contact	
3	18.0	Could discern line between satellites	
4	19.0	Position angle III to II	8° 42′
5	——	Dist. 2″.62	P 0° 57′
6	——	3″.29	359° 22′
7	13:25.0	3″.82	356° 0′
8	26.9	4″.13	354° 14′
9	28.8	4″.90	353° 36′
10	30.7	5″.56	351° 14′

The relative dimensions of the satellites were determined by a series of measures made on two nights about the time of this eclipse.



ECLIPSE OF IV BY III AUG. 3, 1914, 17:18.1 G.M.T.

OBSERVED CIRCUMSTANCES OF THE ECLIPSE.

	G.M.T.		
1	17:14.6	First contact	
2	24.1	A little past second contact, about ⅛ diam. IV apart	
3	27.1	About 1 diam. IV apart. Position angle III to IV	46° 30′
4	30.6		P 52° 55′
5	32.1		55° 33′
6	33.6		57° 8′
7	35.4		58° 19′
8	38.5	Distance 6″.29 No measure of P.	

As only one distance was measured the apparent path of IV relative to III was assumed to be a straight line perpendicular to the axis of Jupiter with IV moving with uniform motion.

The G.·M. T. of the eclipse of II by I July 22, 1914 was 20:46.15, the mean of first contact, 20:43.3 and, of second contact, 20:49.0. The combined image seemed at its shortest elongation at 20:45.3.

The following phenomena of satellites were noted:

III Oc. Re.	July 17,	19:17.1	G.M.T.	III Tr. In.	Aug. 18,	13:13.0	G.M.T.
I Sh. In.	" 25,	17:48.2	"	II Ec. Re.	" 21,	18:13.088	"
I Tr. In.	" "	18: 5.2	"	IV Oc. Re.	Sept. 21,	14:31.6	"
II Tr. Eg.	" 29,	16:46.5	"	II Ec. Re.	" 15,	15:19.607	"
I Sh. Eg.	Aug. 3,	16:22.1	"	I Ec. Re.	" 26,	16:5.425	"
I Tr. Eg.	" "	16:31.8	"	I Tr. Eg.	Nov. 2,	12:43.9	"
I Tr. In.	" 10,	15:58.8	"	I Ec. Re.	" 4,	14:40.103	"

The following are the longitudes of the Red Spot, the preceding and the following ends of the Disturbance, reduced from micrometric measures of their coördinates. The reductions of latitude—whose means are given elsewhere—were made by Whitmell's formulae and those of longitude by one of·our own.

RS		pD		fD	
Apr. 5	223°.7	Apr. 9	119°.1	June 7	236°.1
May 28	217.7	May 10	107.2	" 12	238.6
" 31	215.5	" 20	110.2	Aug. 13	180.6
June 7	212.8	" 27	104.7	" 18	177.5
" 16	212.5	June 11	98.5	" 21	180.8
July 22	208.1	" 20	90.4	Sept. 14	173.0
" 25	208.1	July 17	88.1	" 19	169.7
" 30	209.5	" 21	79.7	" 21	156.8
Aug. 3	209.3	" 22	80.1	" 28	166.8
" 13	207.6	" 29	75.7	Oct. 1	167.3
" 16	205.7	Aug. 6	73.5	" 20	162.2
" 18	211.8	" 10	70.9	Dec. 17	107.1
" 21	208.3	" 13	69.6		
Sept. 12	204.5	" 15	70.4		
" 14	205.5	" "	68.4		
" 18	211.8	" 18	71.8		
" 21	206.8	Sept. 16	62.7		
" 22	208.9	Oct. 10	56.1		
" 26	202.3	" 17	52.9		
" 30	207.1	" 19	50.2		
Oct. 20	205.0	" 27	42.9		
Nov. 4	202.9	Dec. 16	25.1		
" 11	199.7	Jan. 26	24.7		

It should be remarked concerning the drawings that the contrasts are greater than actually seen, especially in regard to the Red Spot, whose outlines could be distinguished only with difficulty. It was never perfectly certain whether the ends were pointed or rounded; but the drawing gives our best impression. The minute elongated marking seen August 10 in the N following part of the equatorial zone is the shadow of I protruding from behind the disk of the satellite that partly covers it.

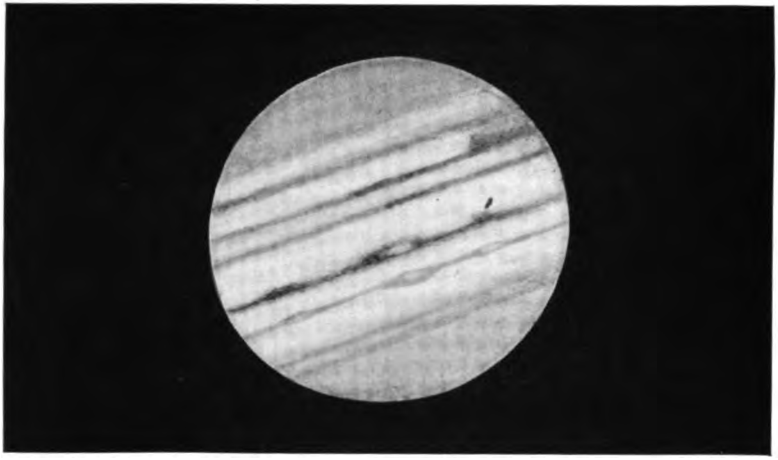
Daniel Scholl Observatory,
Lancaster, Pa. October, 1915.

THE PLANET MERCURY.

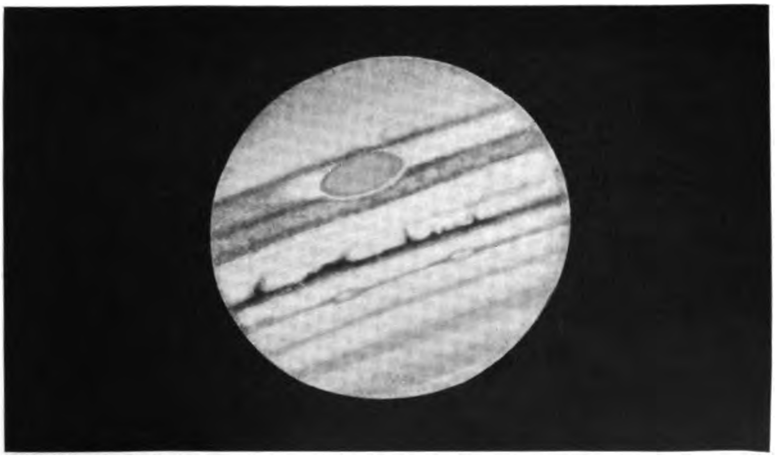
BERNARD THOMAS.

The 'swift messenger of the gods' which seems to be a difficult and illusive object to see with the naked eye in northern countries is here in Tasmania by no means hard to observe. For some years now I have attempted to see this beautiful and interesting planet as an evening star on as many occasions as possible when favorably placed during our spring about October, and have succeeded far beyond what I thought was possible. During this time if the sky is free from clouds in the west and south west with some knowledge where to look and what to expect, with a little patience in waiting for a break when some clouds were present, I succeeded last year in seeing him 28 times when in the region of Virgo and the Scorpion in spite of the fact that the weather was then rather unfavorable. I saw him first 18 days before greatest eastern elongation and thirteen days after. Thus he was visible during a period of thirty-three days. This is duly recorded in the *English Mechanic* for January 15, 1915. This year I had even better luck as he was seen twenty-nine times from September 5 to October 12, twenty-three days before and fourteen days after greatest elongation. He was last seen 10.2 days before inferior conjunction, followed thus during a period of thirty-seven days. The following particulars from the *Nautical Almanac* (time corrected to local mean time).

PLATE VII



August 10, 1914, 16^{h} 35^{m} G. M. T.



August 18, 1914, 18^{h} 35^{m} G. M. T.

DRAWINGS OF JUPITER IN 1914, BY A. THOS. G. APPLE

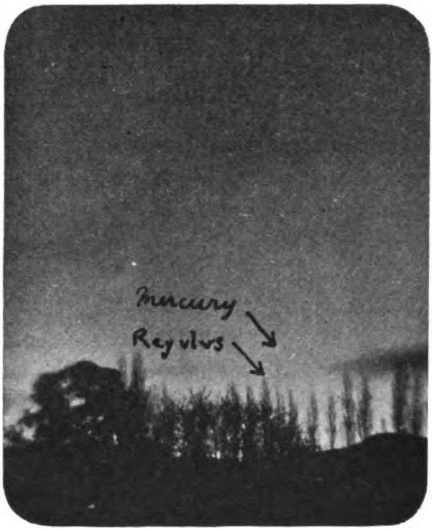
Aug. 14	7 p.m.	☿ Sup. ☌ ☉
Sept. 6	4 p.m.	☿ in ☋
11	3:50 p.m.	☿ ☌ ☾ ☿ 3° 51′ N
16		☿ in Aphelion
22	1 a.m.	☿ ☌ α Virginis star 1′ S
28	3 p.m.	☿ G. E. E. 26° 2′ E
Oct. 7	8 a.m.	☿ G. Hel. Lat. S
10	1:36 a.m.	☿ ☌ ☾ ☿ 1° 40′ N
22-23	Midnight	☿ Inf. ☌ ☉

In all cases he was seen clearly and distinctly usually in a clear sky and only on one or two occasions had I to wait and watch for a break in the clouds. That this planet could be so successfully followed for so large a period of his revolution is explained by his favorable position south of the sun and also of the ecliptic as well as by the general clearness of that part of the heavens.

Colour. My observations on this point lead me to consider that much depends on altitude. It has been said that Mercury is really white but as a naked eye object an evening star sufficiently elevated against a dark blue sky he is decidedly golden yellow. He seems to be about the same tint as α Centauri—probably Capella might compare with him. He has not such an orange tinge as Arcturus. In the eight-and-a-half inch reflector when I had my most favorable view of him his colour seemed to be ochre. But more often the lower strata of the atmosphere cause refraction and the planet is seen with a splotch of rich red above and bright blue beneath, reminding one of a bad attempt by some child to color the planet with a faulty attempt to correctly cover the outline. This appearance of the spectrum is due to no lack of achromation of telescope or eyepiece but to atmospheric dispersion and can be seen on Venus, Jupiter, the Moon or even bright stars when at a low altitude.

Magnitude. Most accounts of naked eye observations of Mercury make the magnitude of the planet much too faint. I have seen Mercury in close proximity to Regulus, magnitude 1.34 Type B8, Spica, magnitude 1.20 Type B2 and Antares, magnitude 1.22 Type Map, when Mercury exceeded in brightness each of these stars by a full magnitude if not more. I have compared him to Antares, magnitude 0.24, when he seemed if anything brighter and only a little fainter than α Centauri 0.06. When he is seen against the colorless sky of early twilight or against the zodiacal light his brilliancy is considerably dimmed but if we wait till the sky is a dark blue and if Mercury is still above the horizon his extreme brilliancy is better estimated. I usually found that I could find him in the early twilight when I could discern α Crucis magnitude 1.03, or β Centauri, magnitude 0.86, with the naked eye but these stars were against a darker sky and at greater altitude. Personally I take the magnitude of Mercury to be about 0.20 or 0.10.

I enclose a photo trail taken a few years ago of Mercury and Regulus when about a degree apart. It will be seen that the upper trail, that of Mercury, is much brighter than that of Regulus although the star is of the photographically active type B8.



TRAILS OF MERCURY AND REGULUS.

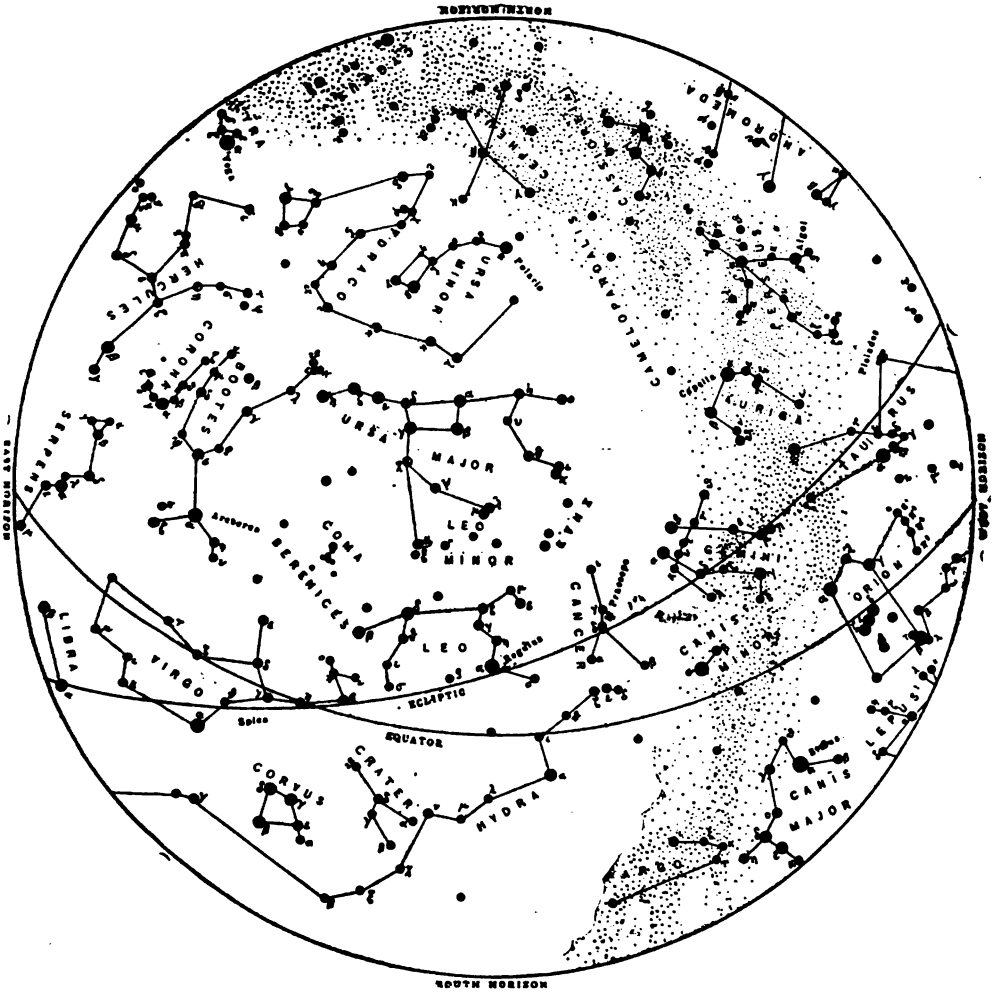
Telescopic appearance. As a telescopic object Mercury is usually disappointing. Of the twenty nine occasions on which I saw him this time I used the telescope on about twenty. Half of these views showed only a blur, the other half I could see the phase and it was interesting to watch it change from a gibbous moon 6″ to a crescent 9″ in diameter. On all but two occasions the spectrum and other disabilities were present. Once only had I a perfect view of the half moon phase with clear limb and only a little less well defined terminator free from tremor of a bright ochre color but with no markings. A power of 160 was used on the eight-and-one-half-inch reflector. I have previously had very fair views of Mercury with a two-inch refractor and power of 34 to 90.

I missed the close approach of Spica and Mercury owing to weather. I have however seen Mercury and Regulus in the same low power field of the the two-inch refractor. Mercury was golden, slightly orange, Regulus was steel blue, a beautiful contrast.

Glenorchy, Tasmania.

PLANET NOTES FOR APRIL, 1916.

The sun will move by a northeasterly course from Pisces into Aries during this month. The sun will not pass very near to any conspicuously bright star. At the end of the month it will be nearing the region of the Pleiades.



THE CONSTELLATIONS AT 9:00 P. M. APRIL 1.

The phases of the moon for this month are as follows:

New Moon	Apr. 2	at	10	A.M.	C.S.T.
First Quarter	10	"	9	A.M.	"
Full Moon	17	"	11	P.M.	"
Last Quarter	24	"	5	P.M.	"

Mercury will be too near the sun to be observed during this month. At the beginning of the month it will be to the west of the sun, and approaching it. It will be moving around behind the sun from the earth, and will pass to the east of the sun on April 14. It will then move farther and farther to the east but will scarcely emerge far enough to become visible before the close of the month.

Venus will be moving eastward from the sun up to April 23, at which time it will reach a point of greatest eastern elongation. At this date it will cross the meridian about 3 o'clock and will still be high in the western sky at sunset. Venus will be approaching the earth and will be increasing in brightness. Only about one half of the illuminated surface will be seen.

Mars will continue to be in very good position for observation. It will cross the meridian early in the evening during this month. It will be receding from the earth.

Jupiter will be in conjunction with the sun on April 1. The sun will be passing the planet as the sun moves eastward more rapidly. Jupiter will again appear in the east just before sunrise late in the month and early in May.

Saturn will be a little west of the meridian at sunset early in April, and will be lower in the west on each succeeding day. It will be in fairly good position throughout the month.

Uranus may be seen in the southeast in the early morning during the month. It is in the constellation Capricornus.

Neptune like Saturn will be visible in the early evening. It will be in the constellation Cancer, but not near any very bright star.

Occultations Visible at Washington.

Date 1916	Star's Name	Magnitude	IMMERSION. Washington M.T.		IMMERSION. Angle f'm N.	EMERSION. Washington M.T.		EMERSION. Angle f'm N.	Duration	
			h	m	°	h	m	°	h	m
Apr. 6	ψ Tauri	5.3	6	31	91	7	46	270	1	15
9	ω Geminorum	5.2	6	14	128	7	40	271	1	25
13	43 Leonis	6.3	11	46	154	12	48	276	1	2
16	370 B Virginis	6.0	16	6	35	16	19	10	0	13
17	75 Virginis	5.6	6	47	111	7	46	309	0	59
19	153 B Librae	6.3	8	45	107	9	44	297	1	0
19	*b* Scorpii	4.7	18	11	135	18	57	232	0	46
24	19 Capricorni	5.7	13	44	113	14	34	211	0	50

Saturn's Satellites for April, 1916.

CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.

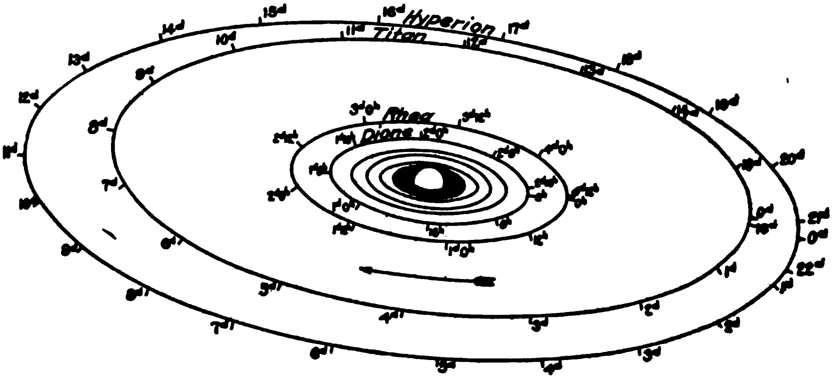
I. Mimas. Period $0^d\ 22^h.6$.

	d	h		d	h		d	h		d	h
Apr.	1	12.5 E	Apr.	8	14.3 W	Apr.	16	14.6 E	Apr.	23	16.2 W
	2	11.2 E		9	13.0 W		17	13.3 E		24	14.8 W
	5	18.4 W		12	11.6 W		18	11.9 E		25	13.4 W
	6	17.0 W		14	17.4 E		22	17.6 W		26	12.1 W
	7	15.6 W		15	16.0 E						

Saturn's Satellites for April, 1916—Continued.

II. Enceladus. Period 1^d 8^h.9 .

	d	h		d	h		d	h		d	h
Apr.	1	19.5 E	Apr.	10	0.9 E	Apr.	18	6.3 E	Apr.	25	2.8 E
	3	4.4 E		11	9.8 E		19	15.2 E		26	11.7 E
	4	13.3 E		12	18.7 E		21	0.1 E		27	20.6 E
	5	22.2 E		14	3.6 E		22	9.0 E		29	5.5 E
	7	7.1 E		15	12.5 E		23	17.9 E		30	14.4 E
	8	16.0 E		16	21.4 E						



Apparent Orbits of the Seven Inner Satellites of Saturn, at date of Opposition, January 4, 1916, as seen in an Inverting Telescope.

III. Tethys. Period 1^d 21^h.3.

Apr.	2	7.4 E	Apr.	9	20.7 E	Apr.	17	10.0 E	Apr.	24	23.3 E
	4	4.8E		11	18.1 E		19	7.4 E		26	20.6 E
	6	2.1 E		13	15.4 E		21	4.7 E		28	18.0 E
	7	23.4 E		15	12.7 E		23	2.9 E		30	15.3 E

IV. Dione. Period 2^d 17^h.7.

Apr.	2	9.4 E	Apr.	10	14.5 E	Apr.	18	19.7 E	Apr.	27	0.8 E
	5	3.1 E		13	8.2 E		21	13.4 E		29	18.6 E
	7	20.8 E		16	1.9 E		24	7.1 E			

V. Rhea. 4^d 12^h.5.

Apr.	3	3.7 E	Apr.	12	4.7 E	Apr.	21	5.7 E	Apr.	30	6.8 E
	7	16.2 E		16	17.2 E		25	18.2 E			

VI. Titan. Period 15^d 23^h.3.

Apr.	2	0.8 W	Apr.	10	7.6 E	Apr.	18	0.5 W	Apr.	26	7.5 E

VII. Hyperion. Period 21^d 7^h.6.

Apr.	2	17.8 E	Apr.	14	12.4 W	Apr.	24	4.7 E

VIII. Japetus. Period 79^d 22^h.1.

Apr.	3	7.3 W	Apr.	22	20.1 S

IX. Phoebe. Period 523^d 15^h.6.

		α Ph.—α Sat.		δ Ph.—δ Sat.				α Ph.—α Sat.		δ Ph.—δ Sat.	
		m	s	′	″			m	s	′	″
Apr.	2	−1	13.8	+2	37	Apr.	18	−1	31.3	+2	29
	4	1	16.1	2	36		20	1	33.4	2	29
	6	1	18.4	2	35		22	1	35.3	2	28
	8	1	20.6	2	34		24	1	37.3	2	28
	10	1	22.8	2	33		26	1	39.1	2	27
	12	1	25.0	2	32		28	1	41.0	2	27
	14	1	27.2	2	31		301	−4	2.8	+2	27
	16	−1	29.3	+2	30						

VARIABLE STARS.

Approximate Magnitudes of Variable Stars of Long Period on Feb. 1, 1916.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.		Decl. 1900.		Magn.
	h	m	°	′	
X Androm.	0	10.8	+46	27	12.8 *i*
T Androm.		17.2	+26	26	13.0*d*
T Cassiop.		17.8	+55	14	8.3 *i*
R Androm.		18.8	+38	1	<14.0
S Ceti		19.0	— 9	53	10.5*d*
Y Cephei		31.3	+79	48	10.5*d*
U Cassiop.		40.8	+47	43	13.3*d*
RW Androm.		41.9	+32	8	14.0
V Androm.		44.6	+35	6	11.6*d*
RR Androm.		45.9	+33	50	13.7*d*
RV Cassiop		47.1	+46	53	13.0*d*
W Cassiop.		49.0	+58	1	11.5 *i*
Z Ceti	1	1.6	— 2	1	12.8 *i*
U Androm.		9.8	+40	11	11.6*d*
UZ Androm.		10.4	+41	12	13.0
S Cassiop.		12.3	+72	5	<14.0
S Piscium		12.4	+ 8	24	9.5
U Piscium		17.7	+12	21	10.3 *i*
RZ Persei		23.6	+50	20	13.2
R Piscium		25.5	+ 2	22	12.5*d*
RU Androm.		32.8	+38	10	13.1*d*
Y Androm.		33.7	+38	50	13.5*d*
X Cassiop.		49.8	+58	46	11.0
U Persei		53.0	+54	20	8.0 *i*
S Arietis		59.3	+12	3	13.5
R Arietis	2	10.4	+24	35	10.0 *i*
W Androm.		11.2	+43	50	11.5 *i*
Z Cephei		12.8	+81	13	12.0 *i*
o Ceti		14.3	— 3	26	4.0*d*
S Persei		15.7	+58	8	9.0
R Ceti		20.9	— 0	38	8.5*d*
RR Persei		21.7	+50	49	13.0*d*
U Ceti		28.9	—13	35	11.8*d*
RR Cephei		29.4	+80	42	11.0 *i*
R Trianguli		31.0	+33	50	7.4 *i*
W Persei		43.2	+56	34	10.0
U Arietis	3	5.5	+14	25	11.0 *i*
X Ceti		14.3	— 1	26	11.0*d*
Y Persei		20.9	+43	50	9.8
R Persei		23.7	+35	20	<13.5
W Tauri	4	22.2	+15	49	9.8
R Tauri		22.8	+ 9	56	13.5 *i*
S Tauri		23.7	+ 9	44	14.7
T Camelop.		30.4	+65	57	9.8 *i*
X Camelop.		32.6	+74	56	13.0
RX Tauri		32.8	+ 8	9	10.3*d*
V Tauri		46.2	+17	22	11.5*d*
R Orionis		53.6	+ 7	59	11.4 *i*
R Leporis		55.0	—14	57	8.3*d*
T Leporis	5	0.6	—22	2	9.3*d*
V Orionis		0.8	+ 3	58	9.5
R Aurigae		9.2	+53	28	12.0 *i*
W Aurigae	5	20.1	+36	49	13.3
S Aurigae		20.5	+34	4	9.0
S Orionis		24.1	— 4	46	10.0*d*
S Camelop.		30.2	+68	45	9.8*d*
T Orionis		30.9	— 5	32	10.0*d*
U Aurigae		35.6	+31	59	11.0
SU Tauri		43.2	+19	2	9.5
Z Tauri		46.7	+15	46	<13.0
RU Tauri		46.9	+15	57	13.0
V Camelop.		49.4	+74	30	9.8*a*
U Orionis		49.9	+20	10	12.0*d*
Z Aurigae		53.6	+53	18	10.6
X Aurigae	6	4.4	+50	15	11.0*d*
SS Aurigae		5.8	+47	46	10.5
V Aurigae		16.5	+47	45	9.3
V Monoc.		17.7	— 2	9	7.6*d*
U Lyncis		31.8	+59	57	13.0 *i*
S Lyncis		35.9	+58	0	10.5*d*
X Geminorum		40.7	+30	23	12.5*d*
W Monoc.		47.5	— 7	2	10.8
Y Monoc.		51.3	+11	22	11.4*d*
X Monoc.		52.4	— 8	56	8.7
R Lyncis		53.0	+55	28	9.2
R Geminorum	7	1.3	+22	52	10.0*d*
V Can. Min.		1.5	+ 9	2	13.5*d*
R Can. Min.		3.2	+10	11	9.8
RR Monoc.		12.4	+ 1	17	12.8 *i*
V Geminorum		17.6	+13	17	13.3
S Can. Min.		27.3	+ 8	32	8.4*d*
Z Puppis		28.3	—20	27	<13.0
T Can. Min.		28.4	+11	58	12.3
U Can. Min.		35.9	+ 8	37	8.0
S Geminorum		37.0	+23	41	<13.5
T Geminorum		43.3	+23	59	12.4*d*
U Geminorum		49.2	+22	16	<13.5
U Puppis		56.1	—12	34	<13.5
R Cancri	8	11.0	+12	2	9.4 *i*
V Cancri		16.0	+17	36	7.8 *i*
RT Hydrae		24.7	— 5	59	8.0
U Cancri		30.0	+19	14	13.3*d*
X Urs. Maj.		33.7	+50	30	13.0
S Hydrae		48.4	+ 3	27	9.2
T Hydrae		50.8	— 8	46	9.0
T Cancri		51.0	+20	14	9.6
S Pyxidis	9	0.7	—24	41	11.0
W Cancri		4.0	+25	39	<13.5
X Hydrae		30.7	—14	15	9.6 *i*
Y Draconis		31.1	+78	18	<13.5
R Leo. Min.		39.6	+34	58	7.2
RR Hydrae		40.4	—23	34	12.0 *i*
R Leonis		42.2	+11	54	7.5*d*
Y Hydrae		46.4	—22	33	6.8

Approximate Magnitudes of Variable Stars of Long Period on Feb. 1, 1916—Continued.

Name.	R. A. 1900.		Decl. 1900		Magn.	Name.	R. A. 1900.		Decl. 1900		Magn.
	h	m	°	′			h	m	°	′	
V Leonis	9	54.5	+21	44	12.6*d*	SV Herculis	18	22.3	+24	58	12.4*d*
R Urs. Maj.	10	37.6	+69	18	8.6*d*	SV Draconis		31.2	+49	18	12.5 *i*
V Hydrae		46.8	—20	43	7.2	RZ Herculis		32.7	+25	58	12.8*d*
W Leonis		48.4	+14	15	12.7*d*	RY Lyrae		41.2	+34	34	10.0 *i*
S Leonis	11	5.7	+ 6	0	12.8*d*	RW Lyrae		42.1	+43	32	13.0*d*
R Com. Ber.		59.1	+19	20	<14.0	RX Lyrae		50.4	+32	42	<14.0
SU Virginis	12	0.0	+12	56	13.2	Z Lyrae		56.0	+34	49	<14.0
T Virginis		9.5	— 5	29	12.2 *i*	RT Lyrae		57.8	+37	22	13.5
R Corvi		14.4	—18	42	11.0 *i*	RU Lyrae	19	9.1	+41	8	13.3*d*
SS Virginis		20.1	+ 1	19	7.1	S Lyrae		9.1	+25	50	<14.0
T Can. Ven.		25.2	+32	3	12.0	RS Lyrae		9.3	+33	15	<14.5
Y Virginis		28.7	— 3	52	8.5 *i*	U Draconis		9.9	+67	7	9.7 *i*
T Urs. Maj.		31.8	+60	2	12.6*d*	TZ Cygni		13.4	+50	0	10.0
R Virginis		33.4	+ 7	32	7.4	U Lyrae		16.6	+37	42	11.5 *i*
RS Urs. Maj.		34.4	+59	2	11.0 *i*	TY Cygni		29.8	+28	6	9.8 *i*
S Urs. Maj.		39.6	+61	38	7.5 *i*	R Cygni		34.1	+49	58	13.0*d*
RU Virginis		42.2	+ 4	42	12.0	RT Cygni		40.8	+48	32	12.3
U Virginis		46.0	+ 6	6	12.8	TU Cygni		43.3	+48	49	12.0*d*
V Virginis	13	22.6	— 2	39	<13.0	χ Cygni		46.7	+32	40	5.7
R Hydrae		24.2	—22	46	8.5 *i*	Z Cygni		58.6	+49	46	9.0
S Virginis		27.8	— 6	41	8.5	S Cygni	20	3.4	+57	42	9.5
T Urs. Min.		32.6	+73	56	13.0*d*	RS Cygni		9.8	+38	28	8.0
R Can. Ven.		44.6	+40	2	7.6	U Cygni		16.5	+47	35	7.2
Z Bootis	14	1.7	+13	59	10.6 *i*	ST Cygni		29.9	+54	38	13.0
Z Virginis		5.0	—12	50	13.0	V Cygni		38.1	+47	47	10.3*d*
U Urs. Min.		15.1	+67	15	8.2*d*	RZ Cygni		48.5	+46	59	12.0
S Bootis		19.5	+54	16	13.0*d*	TW Cygni	21	1.8	+29	0	<13.5
RS Virginis		22.3	+ 5	8	13.0	X Cephei		3.6	+82	40	12.0*d*
R Camelop.		25.1	+84	17	12.2 *i*	T Cephei		8.2	+68	5	7.0
V Bootis		25.7	+39	18	9.1*d*	S Cephei		36.5	+78	10	9.5 *i*
R Bootis		32.8	+27	10	9.3*d*	RU Cygni		37.3	+53	52	9.0
U Bootis		49.7	+18	6	11.6	SS Cygni		38.8	+43	8	8.5
S Serpentis	15	17.0	+14	40	<13.0	RT Pegasi		59.8	+34	38	13.0*d*
S Cor. Bor.		17.3	+31	44	7.5 *i*	RV Pegasi	22	21.0	+29	58	13.0
S Urs. Min.		33.4	+78	58	10.0 *i*	S Lacertae		24.6	+39	48	12.7*d*
R Cor.Bor.		44.4	+28	28	6.0	R Lacertae		38.8	+41	51	11.7*d*
X Cor. Bor.		45.2	+36	35	13.0*d*	S Aquarii		51.8	—20	53	11.0*d*
V Cor. Bor.		46.0	+39	52	8.3	RW Pegasi		59.2	+14	46	10.0*d*
R Serpentis		46.1	+15	26	12.8	R Pegasi	23	1.6	+10	0	8.4*d*
Z Cor. Bor.		52.2	+29	32	<13.0	V Cassiop.		7.4	+59	8	12.0*d*
U Serpentis	16	2.5	+10	12	11.0 *i*	W Pegasi		14.8	+25	44	12.7
W Cor. Bor.		11.8	+38	3	8.5	S Pegasi		15.5	+ 8	22	12.5*d*
U Herculis		21.4	+19	7	11.7	Z Androm.		28.8	+48	16	8.0
R Urs. Min.		31.3	+72	28	10.5	ST Androm.		33.8	+35	13	10.7
R Draconis		32.4	+66	58	10.5 *i*	R Aquarii		38.6	—15	50	9.8*d*
S Herculis		47.4	+15	7	9.0 *i*	Z Cassiop.		39.7	+56	2	<14.0
RV Herculis		56.8	+31	22	12.5 *i*	RR Cassiop.		50.7	+53	8	13.6
T Draconis		54.8	+58	14	12.0	V Ceti		52.8	— 9	31	9.0 *i*
V Draconis		56.3	+54	53	13.0	R Cassiop.		53.3	+50	50	9.5*d*
T Herculis	18	5.3	+31	0	8.0 *i*	Z Pegasi		55.0	+25	21	8.6
W Draconis		5.4	+65	56	9.5	Y Cassiop		58.2	+55	7	13.6
X Draconis		6.8	+66	8	10.0	SV Androm.		59.2	+39	33	13.0
W Lyrae		11.5	+36	38	8.5 *i*						

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—H. C. Bancroft, Jr. T. C. H. Bouton, A. B. Burbeck, L. Campbell, J. J. Crane, H. O. Eaton, W. P. Hoge, S. C. Hunter, O. Mach, C. Y. McAteer, C. S. Mundt, G. F. Nolte, W. T. Olcott, D. B, Pickering, C. F. Richter, F. H. Spinney, H. M. Swartz, H. W. Vrooman, I. E. Woods, and A. S. Young,

Minima of Variable Stars of Short Period.

[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5ʰ; Central Standard 6ʰ; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 April							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.8			19	2				
RT Sculptor.		31.5	—26	13	9.6—10.5	0	12.3	3	6;	10	22;	18	14;	26	6
UU Androm.		38.5	+30	24	10.7—11.9	1	11.7	2	22;	10	8;	17	18;	25	5
U Cephei	0	53.4	+81	20	7.0— 9.0	2	11.8	6	12;	13	23;	21	11;	28	22
Z Persei	2	33.7	+41	46	9.4—12	3	01.4	7	4;	13	7;	25	12;	31	15
TW Cassiop.		37.6	+65	19	8.2— 9.0	1	10.3	7	24;	15	3;	22	7;	29	10
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	1	7;	8	4;	22	21;	29	18
RZ Cassiop.		39.9	+69	13	6.9— 8.1	1	04.7	3	22;	11	1;	18	6;	25	10
TX Cassiop.		44.4	+62	22	9.4—10.1	2	22.2	3	22;	12	16;	21	11;	30	6
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	4	13;	12	11;	20	10;	28	9
RX Cassiop.	2	58.8	+67	11	8.6— 9.1	32	07.6			16	21				
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	2	19;	8	11;	20	22;	25	16
RT Persei		16.7	+46	12	9.5—11.5	0	20.4	7	5;	14	0;	20	19;	27	14
λ Tauri		55.1	+12	12	3.3— 4.2	3	22.9	7	8;	15	5;	23	3		
RW Tauri	3	57.8	+27	51	7.1—<11	2	18.5	1	20:	10	3;	18	10;	26	18
RV Persei	4	04.2	+33	59	9.5—11.0	1	23.4	4	7;	12	4;	20	2;	27	23
RW Persei		13.3	+42	04	8.8—11.0	15	04.8	1	5;	14	10;	27	15		
SZ Tauri		31.4	+18	20	7.2— 7.7	3	03.6	2	8;	11	19;	21	5;	30	16
RS Cephei	4	48.6	+80	06	9.5—12.0	12	10.1			11	20;	24	6		
TT Aurigae	5	02.8	+39	27	7.8— 8.7	0	16.0	4	9;	11	1;	17	17;	24	9
RY Aurigae		11.5	+38	13	10.7—11.7	2	17.5	5	23;	11	10;	21	8;	26	19
RZ Aurigae		42.9	+31	40	10.6—13.3	3	00.3	6	17;	12	17;	24	18;	30	19
SV Tauri		45.8	+28	05	9.4—11.0	2	04.0	8	22;	17	14;	26	6		
Z Orionis		50.2	+13	40	9.7—10.7	5	04.9	6	13;	16	22;	27	8		
SV Gemin.		54.6	+24	28	9.8—<11	4	00.2	8	11;	16	12;	24	12		
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	5	0;	10	17;	22	4;	27	22
U Columbae	6	11.2	—33	03	9.2—10.0	2	19.2	5	19;	11	10;	22	15;	28	5
SX Gemin.		22.0	+20	37	10.8—11.5	1	08.8	1	21;	10	2;	18	7;	26	12
RW Monoc.		29.3	+ 8	54	9.0—10.8	1	21.7	5	2;	12	17;	20	8;	27	23
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0	7	1;	19	16				
RU Monoc.	6	49.4	— 7	28	9.8—10.5	0	21.5	2	7;	9	11;	16	15;	30	23
R Can. Maj.	7	14.9	—16	12	5.8— 6.4	1	03.3	2	1;	11	3;	20	5;	29	7
RY Gemin.		21.7	+15	52	8.9—<10	9	07.2	9	14;	18	21;	28	4		
Y Camelop.		27.6	+76	17	9.5—12	3	07.3	3	6;	13	5;	23	3;	33	1
TX Gemin.		30.3	+17	8	10.0—11.9	2	19.2	3	5;	11	15;	20	0;	28	10
RR Puppis		43.5	—41	08	9.4—10.7	6	10.3	9	7;	15	18;	22	4;	28	14
V Puppis	7	55.4	—48	58	4.1— 4.8	1	10.9	1	11;	8	18;	23	7;	30	13
X Carinae	8	29.1	—58	53	7.9— 8.7	0	13.0	2	16;	10	19;	18	22;	27	1
S Cancri	8	38.2	+19	24	8.2—10	9	11.6	2	5;	11	16;	21	4;	30	16
RX Hydrae	9	00.8	— 7	52	9.1—10.5	2	6.8	1	19;	10	22;	20	1;	29	4
S Antliae		27.9	—28	11	6.7— 7.3	0	07.8	5	8;	11	20;	18	7;	24	19
S Velorum		29.4	—44	46	7.8— 9.3	5	22.4	6	16;	18	13;	24	11;	30	10
Y Leonis	9	31.1	+26	41	9.3—11.2	1	16.5	9	4;	17	15;	26	1		
RR Velorum	10	17.8	—41	36	10.0—10.9	1	20.5	1	10;	10	16;	19	23;	29	5
SS Carinae	10	54.2	—61	23	12.2—12.8	3	07.2	6	1;	12	16;	19	6;	25	21
ST Urs. Maj.	11	22.4	+45	44	6.7— 7.2	8	19.2	3	0;	11	19;	20	14;	29	10
RW Urs. Maj.		35.4	-+52	34	10.3—11.4	7	07.9	4	17;	12	1;	19	8;	26	16
Z Draconis	11	39.8	+72	49	9.9—13.6	1	08.6	5	23;	12	17;	19	12;	26	7
RZ Centauri	12	55.6	- 64	05	8.5— 8.9	1	21.0	5	7;	12	19;	20	7;	27	19
RS Can. Ven.	13	06.3	+36	28	7.5—12.5	4	19.2	5	13;	15	4;	24	18		
SS Centauri	13	07.2	—63	37	8.8—10.4	2	11.5	4	17;	12	4;	19	14;	27	1
δ Librae	14	55.6	— 8	07	4.8— 6.2	2	07.9	6	5;	13	4;	20	4;	27	3

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 April							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
U Coronae	15	14.1	+32	01	7.6— 8.7	3	10.9	6	16;	13	14;	20	12;	27	9
TW Draconis		32.4	+64	14	7.3— 8.9	2	19.4	6	21;	15	7;	23	17		
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	1	23;	9	15;	17	7;	24	22
SW Ophiuchi	16	11.1	— 6	44	9.2—10.0	2	10.7	5	10;	12	18;	20	2;	27	10
SX Ophiuchi		12.6	— 6	25	10.5—11.2	2	01.5	7	23;	16	5;	24	11		
R Arae		31.1	−56	48	6.8— 7.9	4	10.2	9	19;	18	15;	27	12		
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1	1	2;	12	3;	21	20		
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	4	0;	10	19;	17	14;	24	10
U Ophiuchi		11.5	+ 1	19	6.0— 6.7	0	20.1	1	8;	9	18;	18	3;	26	12
u Herculis		13.6	+33	12	4.6— 5.4	2	01.2	4	10;	10	13;	22	21;	29	0
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	3	4;	10	9;	17	14;	24	19
RV Ophiuchi		29.8	+ 7	19	9. —12	3	16.5	1	15;	9	0;	16	9;	23	18
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	3	16;	11	21;	20	1;	28	5
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	5	16;	13	5;	20	18;	28	7
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	8	5;	16	22;	24	16		
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	2	2;	10	1;	18	1;	26	1
WX Sagittae		53.6	—17	24	9.2—10.8	2	03.1	7	7;	15	19;	24	7		
WY Sagittae	17	54.9	—23	1	9.5—10.6	4	16.0	2	14;	11	22;	21	6;	30	14
SX Draconis	18	03.0	+ 58	23	9.3—10.5	5	04.1	3	20;	14	4;	24	12		
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	4	11;	11	17;	18	23;	26	5
V Serpentis		11.1	−15	34	9.5−11.1	3	10.9	3	3;	10	1;	23	20;	30	18
RZ Scuti		21.1	— 9	15	7.4— 8.3	15	03.2	1	22;	17	1				
RZ Draconis		21.8	+58	50	9.5−10.2	0	13.2	9	2;	17	9;	25	15		
RX Herculis		26.0	+12	32	7.0− 7.6	0	21.3	6	12;	15	10;	24	7		
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	1	18;	10	2;	18	9;	26	16
RR Draconis		40.8	+62	34	9.3−13	2	19.9	5	1;	13	13;	22	1		
ZR Ophiuchi										13	14				
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	4	17;	10	22;	24	5;	30	21
β Lyrae		46.4	+33	15	3.4— 4.1	12	21.8	6	4;	19	2				
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	7	7;	16	20;	26	9		
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	3	11;	11	1;	18	14;	26	4
RV Lyrae		12.5	+32	15	11. —12.8	3	14.4	1	23;	9	3;	23	13;	30	18
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	1	13;	10	12;	19	11;	28	10
U Sagittae		14.4	+19	26	6.5− 9.0	3	09.1	6	15;	13	10;	20	4;	26	22
Z Vulpec.		17.5	+25	23	7.3− 8.5	2	10.9	7	5;	14	14;	21	22;	29	7
TT Lyrae		24.3	+ 41	30	9.3−11.6	5	05.8	6	3;	11	9;	16	14;	27	2
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	11	19;	11	7;	24	8;	30	21
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	4	11;	10	11;	22	11;	28	11
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	1	22;	8	13;	21	20;	28	11
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	7	12;	16	15;	25	19		
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	6	0;	14	11;	22	21		
RW Capric.		12.2	—17	59	8.8−10.6	3	09.4	5	19;	12	14;	19	9;	26	3
UW Cygni		19.6	+42	55	10.5−13	3	10.8	2	14;	9	12;	23	7;	30	5
V Vulpec.		32.3	+26	15	8.2—9.8	37	19.0			30	0				
W Delphini		33.1	+17	56	9.4−12.1	4	19.4	7	14;	17	5;	26	20		
RR Delphini		38.9	+13	35	10.5−11.8	4	14.4	7	9;	16	14;	25	19		
Y Cygni		48.1	+34	17	7.1− 7.9	1	12.0	7	14;	15	2;	22	14;	30	2
WZ Cygni		49.3	+38	27	9.9−10.8	0	14.0	2	13;	8	9;	20	1;	25	22
RR Vulpec.	20	50.5	+27	32	9.6−11.0	5	01.2			10	1;	20	4;	30	6
VV Cygni	21	02.3	+45	23	12.1−13.8	1	11.4	1	20;	9	5;	16	14;	23	23
AE Cygni		09.0	+30	20	10.8−11.4	0	23.3	3	11;	13	3;	22	20		
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	6	0;	13	21;	21	8;	29	15
UZ Cygni		55.2	+43	52	8.9−11.6	31	07.3			17	12				
RT Lacertae	21	57.4	+43	24	9.1−10.5	5	01.7	2	10;	12	13;	22	17		
RW Lacertae	22	40.6	+49	08	10.2−11.2	5	04.4	5	11;	10	16;	20	25;	26	5
X Lacertae	22	45.0	+55	54	8.2− 8.6	5	10.6	1	20;	12	18;	23	15;	29	1
TT Androm.	23	08.7	+45	36	11.3−12.6	2	18.3	2	17;	11	0;	19	7;	27	14
Y Piscium		29.3	+ 7	22	9.0−12.0	3	18.4	3	15;	11	4;	18	16;	26	5
TW Androm.	23	58.2	+32	17	8.6−11.5	4	02.9	8	8;	16	14;	24	19		

Maxima of Variable Stars of Short Period.

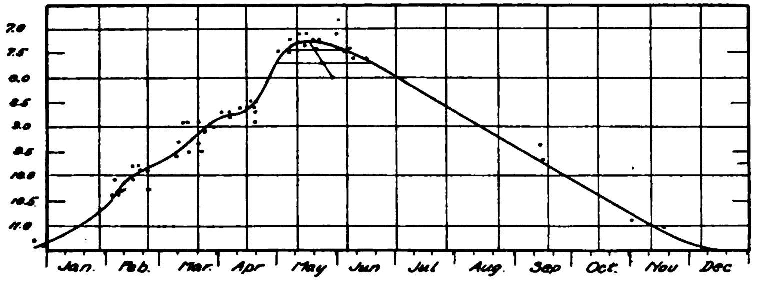
[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5ʰ; Central standard time 6ʰ; etc.

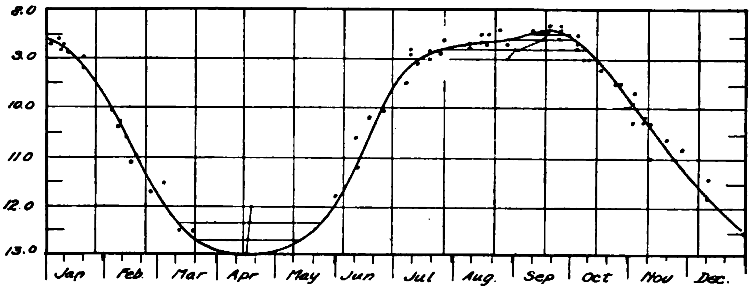
Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. April							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SX Cassiop.	0	05.5	+54	20	8.6— 9.4	36	13.7			29	17				
SY Cassiop.	0	09.8	+57	52	9.3— 9.9	4	1.7	1	22;	10	1;	18	4;	26	8
RR Ceti	1	27.0	+0	50	8.3— 9.0	0	13.3	7	4;	14	22;	22	15;	30	9
RW Cassiop.	1	30.7	+57	15	8.9—11.0	14	19.2			15	17;	30	12		
V Arietis	2	09.6	+11	46	8.3— 9.0	0	23.8	2	18;	10	16;	18	15;	26	13
SU Cassiop.	2	43.0	+68	28	6.5— 7.0	1	22.8	1	8;	9	3;	16	22;	24	17
TU Persei	3	01.8	+52	49	11.4—12.2	0	14.6	6	13;	13	20;	21	3;	28	10
RW Camelop.	3	46.2	+58	21	8.2— 9.4	16	00.0	7	0;	23	0				
SX Persei	4	10.2	+41	27	10.4—11.2	4	07.0	6	3;	14	17;	23	6		
SV Persei		42.8	+42	07	8.8— 9.6	11	03.1	3	22;	15	1;	26	5		
RX Aurigae	4	54.5	+39	49	7.2— 8.1	11	15.0			12	8;	23	23		
SX Aurigae	5	04.6	+42	02	8.0— 8.7	1	12.8	8	14;	16	6;	23	22		
SY Aurigae		05.5	+42	41	8.4— 9.5	10	03.3	1	14;	11	18;	21	21		
Y Aurigae		21.5	+42	21	8.6— 9.6	3	20.6	8	4;	15	21;	23	14		
RZ Gemin.	5	56.6	+22	15	9.1—10.0	5	12.7	1	11;	7	0;	18	1;	29	3
RS Orionis	6	16.5	+14	44	8.2— 8.9	7	13.6	6	18;	14	8;	21	21;	29	11
T Monoc.		19.8	+7	08	5.7— 6.8	27	00.3			24	18				
RZ Camelop.		23.7	+67	06	11.0—13.0	0	11.5	5	8;	12	13;	19	17;	26	22
W Gemin.		29.2	+15	24	6.7— 7.5	7	22.0	6	17;	14	15;	22	13;	30	11
ζ Gemin.	6	58.2	+20	43	3.7— 4.3	10	03.7	2	21;	13	1;	23	5		
RU Camelop.	7	10.9	+69	51	8.5— 9.8	22	06.5	6	12;	28	18				
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	1	1;	9	0;	16	23;	24	21
V Carinae	8	26.7	−59	47	7.4— 8.1	6	16.7	4	15;	11	8;	18	0;	24	17
T Velorum	8	34.4	−47	01	7.6— 8.5	4	15.3	6	23;	16	6;	25	12		
V Velorum	9	19.2	−55	32	7.5— 8.2	4	08.9	3	8;	12	2;	20	19;	29	13
Z Leonis	9	46.4	+27	22	7.9— 9.6	59	0.0								
RR Leonis	10	02.1	+24	29	9.1—10.1	0	10.9	4	23;	11	18;	18	13;	25	8
SU Draconis	11	32.2	+67	53	8.9— 9.6	0	15.8	4	13;	11	3;	24	8;	30	23
S Muscae	12	07.4	−69	36	6.4— 7.3	9	15.8	4	14;	14	5;	23	21		
SW Draconis		12.8	+70	04	8.8— 9.6	0	13.7	3	17;	11	17;	19	16;	27	15
T Crucis		15.9	−61	44	6.8— 7.6	6	17.6	5	9;	12	3;	18	20;	25	14
R Crucis		18.1	−61	04	6.8— 7.9	5	19.8	3	2;	8	22;	20	13;	26	9
S Crucis	12	48.4	−57	53	6.5— 7.6	4	16.6	5	15;	15	0;	24	9;	29	2
W Virginis	13	20.9	−2	52	8.7—10.4	17	06.5	9	20;	27	2				
SS Hydrae		25.0	−23	08	7.4— 8.1	8	4.8	8	5;	16	10;	24	14		
RV Urs. Maj.	13	29.4	+54	31	9.2— 9.9	0	11.2	3	15;	10	16;	17	16;	24	17
ST Virginis	14	22.5	−0	27	10.3—11.4	0	09.9	5	13;	13	7;	21	23;	30	4
V Centauri		25.4	−56	27	6.4— 7.8	5	11.9	4	23;	10	11;	21	11;	26	23
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	5	21;	13	10;	20	23;	28	12
RU Bootis	14	41.5	+23	44	12.8—14.3	0	11.9	2	24;	10	10;	17	20;	25	6
R Triang. Austr.	15	10.8	−66	08	6.7— 7.4	3	09.3	5	18;	12	12;	19	7;	26	2
S Triang. Austr.	15	52.2	−63	29	6.4— 7.4	6	07.8	6	19;	13	3;	19	11;	25	18
S Normae	16	10.6	−57	39	6.6— 7.6	9	18.1	9	18;	19	12;	29	6		
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	5	15;	14	12;	23	9		
RV Scorpii	16	51.8	−33	27	6.7— 7.4	6	01.5	6	22;	13	0;	19	1;	25	3
X Sagittarii	17	41.3	−27	48	4.4— 5.0	7	00.3	4	23;	11	23;	18	23;	26	0
Y Ophiuchi		47.3	−6	07	6.1— 6.5	17	02.9			16	19				
W Sagittarii	17	58.6	−29	35	4.3— 5.1	7	14.3	8	14;	16	4;	23	18		
Y Sagittarii	18	15.5	−18	54	5.4— 6.2	5	18.6	5	19;	11	14;	23	3;	28	22
U Sagittarii		26.0	−19	12	6.5— 7.3	6	17.9	4	3;	10	21;	17	15;	24	8

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. April							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
Y Scuti	18	32.6	− 8	27	8.7— 9.2	10	08.3	9	2;	19	10;	29	18		
Y Lyrae		34.2	+43	52	11.3—12.3	0	12.1	6	2;	12	3;	24	5;	30	6
RZ Lyrae		39.9	+32	42	9.9—11.2	0	12.3	5	14;	11	17;	17	20;	30	3
RT Scuti		44.1	−10	30	9.1— 9.7	0	11.9	4	16;	10	15;	16	14;	28	11
κ Pavonis		46.6	—67	22	3.8— 5.2	9	02.2	3	2;	12	4;	21	6;	30	9
U Aquilae	19	24.0	− 7	15	6.2— 6.9	7	00.6	5	0;	12	2;	19	1;	26	2
XZ Cygni		30.4	+56	10	8.6— 9.3	0	11.2	5	6;	12	6;	19	6;	26	6
U Vulpec.		32.2	+20	07	6.5— 7.6	7	23.5	5	8;	13	8;	21	7;	29	7
SU Cygni		40.8	+29	01	6.2— 7.0	3	20.3	1	17;	9	10;	17	2;	24	19
η Aquilae		47.4	+ 0	45	3.7— 4.5	7	04.2	1	20;	9	1;	23	9;	30	13
S Sagittae		51.5	+16	22	5.6— 6.4	8	09.2	9	1;	17	10;	25	19		
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	4	12:	10	19;	23	11;	29	18
X Cygni	20	39.5	+35	14	6.0— 7.0	16	09.3	1	22;	18	7				
T Vulpec.		47.2	+27	52	5.5— 6.1	4	10.5	1	15;	10	12;	19	9;	28	6
WY Cygni		52.3	+30	03	9.6—10.4	0	13.5	6	5;	12	23;	19	16;	26	10
RV Capric.		55.9	−15	37	9.2—10.1	0	10.7	5	12;	12	5;	18	22;	25	15
TX Cygni	20	56.4	+42	12	8.5— 9.7	14	17.4	6	0;	20	17				
VY Cygni	21	00.4	+39	34	8.8- 9.5	7	20.6	6	18;	14	15;	22	11;	30	8
SW Aquarii		10.2	— 0	20	9.9-10.8	0	11.0	6	23;	13	20;	20	18;	27	15
VZ Cygni	21	47.7	+42	40	8.2- 9.2	4	20.7	3	14;	13	7;	23	1;	27	21
Y Lacertae	22	05.2	+50	33	9.1- 9.6	4	07.8	9	15;	18	7;	26	22		
δ Cephei		25.5	+57	54	3.7- 4.6	5	08.8	4	21;	10	6;	21	0;	26	8
Z Lacertae		36.9	+56	18	8.2- 9.0	10	21.1	2	2;	12	23;	23	20		
RR Lacertae		37.5	+55	55	8.5- 9.2	6	10.1	2	12;	8	23;	21	19;	28	5
V Lacertae	22	44.5	+55	48	8.5— 9.5	4	23.6	2	21;	12	20;	22	19;	27	18
SW Cassiop.	23	03.7	+58	11	9.2— 9.7	5	10.6	4	23;	10	10;	15	20;	26	17
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	5	13;	18	3;	24	10;	30	17
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4	7	0;	19	4				
V Cephei	23	51.7	+82	38	6.0—7.0	0	23.6	2	13;	7	12;	17	12;	27	11



1915 LIGHT CURVE of 081112 R CANCRI Chas B. Lindsley
Maximum May 20, 1915 Cinti, O.
Magnitude 7.2
From observations by Amer Assn of Var. Star Observers.



1915 LIGHT CURVE 142584 R CAMELOPARDALIS
Minimum, Apr 17, (13.0), maximum, Sept 18, (8.4) Chas B Lindsley
From observations by A.A of V S.O. Cin'ti, O.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Jan.-Feb., 1916.

Judging from the paucity of observations contributed this month, and the comments concerning extended periods of cloudiness from observers in various parts of the country, this winter is making a record as regards inclemency. However, a good number of variables have been observed and several important maxima recorded, notably that of the variable *021403* *o* Ceti, with observations in good accordance, and 060547 SS Aurigae. In the case of this latter variable, Mr. Campbell observed a rise of 0.7 magnitude in three hours on the night of January 29. This variable and the irregular variable 054319 SU Tauri are now being closely observed. The latter is an extremely interesting star. It was announced to be variable by Miss Cannon July 13, 1908, and is thought to be one of two stars in the class with 154428 R Cor. Bor. This star is often nearly constant for several years, and the minimum is very faint, probably lower than 15.0 magnitude.

Mr. Bancroft's report for December was received too late for publication in the last issue of POPULAR ASTRONOMY, and is therefore included in this month's report.

The Association is greatly indebted to Mr. C. B. Lindsley for the publication of light curves derived from our observations, especially the annual curve of the variable 213843 SS Cygni. It is hoped that he will continue this valuable service as it enables those interested to note any divergence between the calculated and the observed dates of maxima and minima. Mr. Eaton deserves credit for many valuable early morning observations contributed this month.

Dr. Gray is now located in Portland, Oregon, and Mr. H. L. Baldwin, formerly a resident of Washington, D. C., has moved to Denver, Colorado, and hopes to resume observing in the near future.

It has been considered inadvisable for observers with small glasses to continue observing the variable 175458 T Draconis owing to the proximity of a faint star that renders the identification of the variable difficult.

Variable Star Observations Jan.-Feb., 1916.

001032
S Sculptoris

Mo.	Day	Est.	Obs.
12	31	6.2	R

001726
T Androm.

12	28	11.3	E

001755
T Cassiop.

12	31	9.2	R
1	6	8.3	Bu
	23	7.9	Ba
	24	8.9	S
2	3	9.0	O

001838
R Androm.

1	7	10.7	Hu

001909
S Ceti

12	31	9.0	R
1	2	8.8	Ma

003179
Y Cephei

12	28	9.7	E
1	9	10.0	Hu
	23	10.5	Ba

004047
U Cassiop.

12	28	11.2	E
	31	9.2	R

004435
V Androm.

12	28	9.8	E
1	2	9.9	Hu
	23	10.9	Ba
	29	11.5	O

004533
RR Androm.

12	28	12.7	E

004958
W Cassiop.

12	28	11.7	E
1	23	11.4	Ba

010940
U Androm.

1	23	11.6	Ba

011208
S Piscium

1	3	9.4	V
	24	9.4	V

014958
X Cassiop.

1	24	11.2	Ba

015254
U Persei

Mo.	Day	Est.	Obs.
1	3	8.4	V
	6	8.0	Bu
	24	7.8	Ba
	24	8.4	V

021024
R Arietis

1	29	10.5	O
2	4	10.3	O

021403
o Ceti

12	27	3.1	R
	28	3.0	E
	31	3.0	R
1	2	3.0	E
	2	3.0	Ma
	3	3.3	Mu
	4	3.4	Ly
	4	3.3	Mu
	4	3.2	Pi
	5	2.9	E
	5	3.1	Cr
	5	3.3	Mu
	6	3.0	Cr
	6	3.4	Mu
	6	3.2	O
	6	3.4	Bu
	6	3.0	Pi
	6	3.3	Nt
	7	3.0	Cr
	7	3.3	O
	7	3.0	Pi
	8	3.3	Mu
	8	3.0	M
	9	3.3	O
	9	3.1	Cr
	10	3.3	Ly
	10	3.3	E
	11	2.9	R
	11	3.2	Cr
	14	3.3	E
	14	3.4	Mu
	16	3.3	E
	19	3.4	Mu
	22	3.6	E
	22	3.1	R
	23	3.6	Ma
	23	3.7	E
	23	3.8	Mu
	24	3.8	O
	24	3.7	Cr
	24	4.5	Hu
	24	4.0	Pi
	28	3.9	Mu
	28	3.9	Nt
	28	3.9	Cr
	28	4.0	O
	29	4.0	Nt
	29	4.0	O
	29	3.9	Cr

o Ceti

Mo.	Day	Est.	Obs.
1	31	4.2	Nt
2	3	4.2	O
	4	4.3	O

021658
S Persei

1	6	8.2	Bu
	24	8.7	Ba

022000
R Ceti

1	6	8.0	Bu
	7	7.9	O
	8	8.0	M
	24	8.3	Pi

022150
RR Persei

1	24	13.2	Y

023133
R Triang.

1	6	8.4	Bu
	24	7.9	Hu
	24	7.8	Ba

024356
W Persei

1	7	10.2	Hu
	24	10.3	Ba

030514
U Arietis

1	24	12.5	Ba
	24	12.4	Y

032043
Y Persei

1	7	9.4	Hu
	24	9.7	Ba

033362
U Camelop.

1	2	8.2	Ma

035124
T Eridani

1	7	8.0	Ho

035915
V Eridani

1	7	7.4	Ho

042215
W Tauri

12	11	11.2	Ba
1	4	10.3	Ly
	6	9.6	B
	6	10.2	Pi
	6	10.1	O
	8	9.8	M
	9	9.8	O
	9	9.2	Hu

W Tauri

Mo.	Day	Est.	Obs.
1	10	9.7	Ly
	23	9.5	Ba
	24	9.9	O
	24	10.1	Pi
	29	9.3	B
2	3	9.3	O

043065
T Camelop.

1	24	10.1	Y

043208
RX Tauri

1	6	9.1	O
	6	9.3	Pi
	6	9.5	B
	22	9.9	E
	24	10.3	O
	24	9.3	Hu
	24	9.8	Y
	29	10.2	B
2	4	10.6	O

043274
X Camelop.

1	24	12.8	Y

044617
V Tauri

1	3	10.2	V
	6	10.1	Pi
	6	9.5	B
	24	10.4	V
	24	10.7	Y
	29	11.2	B

045514
R Leporis

1	6	7.4	Bu
	7	7.2	Ho
	7	8.7	Pi
	8	8.6	M
	24	7.5	Ba

050022
T Leporis

1	6	8.2	Bu
	7	8.2	Ho
	7	8.6	Pi
	24	8.7	M
	24	9.4	Y

050003
V Orionis

1	24	10.1	Ba
	25	9.8	M
	29	9.3	O
2	4	9.9	O

052034
S Aurigae

Mo.	Day	Est.	Obs.
1	24	9.2	Pi
	31	8.9	Ba

052405
S Orionis

1	7	9.4	Ho
	8	9.0	M
	24	9.8	Y
	27	10.5	M
	31	9.7	Ba

053068
S Camelop.

1	24	9.7	Y

053005
T Orionis

1	4	9.8	Ly
	4	9.4	Pi
	7	9.5	Sp
	7	9.2	Ho
	8	9.4	M
	31	10.1	Ba

054319
SU Tauri

1	6.5	9.0	O
	7.5	9.5	O
	9.5	9.7	O
	22	9.5	V
	23.5	9.6	Ba
	24	9.7	Y
	24.6	9.6	B
	28.5	9.5	O
2	3.5	9.5	O
	4.5	9.5	O

054920
U Orionis

1	7	11.4	Hu
	7	11.6	Pi
	8	11.5	M
	23	11.0	Hu
	24	11.0	Pi
	24	11.0	Y
	31	11.2	Ba

054974
V Camelop.

12	8	9.5	Ba
	11	9.4	Ba
1	5	9.0	E
	6	8.8	Bu
	6	9.0	O
	7	8.5	Pi
	9	9.0	O
	22	8.9	V
	24	9.7	O
	24	9.0	Y
	29	9.8	O
	31	9.8	Ba
2	3	9.8	O

Variable Star Observations Jan.-Feb., 1916—Continued.

Star	Name	Mo.	Day	Est.	Obs.
055353	Z Aurigae	1	24	10.8	Pi
			31	10.7	Ba
060450	X Aurigae	12	11	8.3	Ba
		1	6	8.8	Bu
			8	9.0	V
			24	10.2	Pi
			26	10.6	V
			31	11.0	Ba
060547	SS Aurigae	1	26.5	12.1	B
			31	10.8	Ba
		2	3.5	10.6	O
			4.5	10.5	O
061702	V Monoc.	1	6	7.8	Bu
			7	6.8	Ho
			31	7.8	Ba
063558	S Lyncis	1	6	9.8	O
			9	9.4	O
			24	10.0	O
			29	10.3	O
			31	10.3	Ba
		2	4	10.4	O
064030	X Geminorum	1	7	11.3	Pi
			31	12.3	Ba
065111	Y Monoc.	1	24	10.8	Y
			31	11.5	Ba
065208	X Monoc.	1	7	8.5	Ho
			8	9.0	M
			31	8.8	Ba
065355	R Lyncis	1	9	8.9	O
			28	9.1	O
		2	4	9.2	O
070109	V Can. Min.	1	24	12.3	Y
070122 a	R Gemin.	1	7	9.3	Hu
			7	9.4	Pi
			24	10.2	O
			24	9.8	M
			31	10.0	Ba
070122	TW Gemin.	1	7	8.4	Pi
			24	8.3	M
070310	R Can. Min.	1	31	10.4	Ba
072708	S Can. Min.	1	2	7.4	Ma
			4	7.2	Ly
			7	7.8	Pi
			8	7.8	M
			10	7.1	Ly
			10	8.0	Mu
			24	8.2	O
			24	8.4	M
			24	8.3	S
			28	8.5	O
			31	8.0	Ba
		2	3	8.6	O
072811	T Can. Min.	1	7	11.9	Sp
			31	12.0	Ba
073508	U Can. Min.	1	6	7.8	Bu
			24	8.7	O
			29	8.2	O
			31	8.3	Ba
		2	3	8.4	O
074323	T Gemin.	1	7	11.0	Pi
			23	11.5	Hu
074922	U Gemin.	1	6.5	13.8	B
081112	R Cancri	1	8	10.0	M
			23	9.6	Hu
			31	9.4	Ba
081617	V Cancri	1	24	8.9	O
			31	8.2	Ba
084803	S Hydrae	1	7	8.2	Sp
			8	8.0	M
	S Hydrae	1	9	10.9	Hu
			31	9.1	Ba
085008	T Hydrae	1	31	9.0	Ba
090151	V Urs. Maj.	12	26	10.2	R
			27	10.1	R
			31	10.1	R
		1	8	9.9	M
			24	10.3	Ba
			25	10.3	V
090425	W Cancri	1	7	12.4	Sp
093934	R Leo. Min.	2	3	7.5	S
094211	R Leonis	1	3	6.4	E
			4	6.8	Ly
			6	7.2	Bu
			7	6.7	Pi
			7	6.4	E
			8	7.2	M
			22	7.0	E
			31	6.8	Ba
		2	3	7.5	S
095421	V Leonis	1	7	10.0	Pi
			7	10.4	Sp
103769	R Urs. Maj.	12	8	7.2	Ba
		1	2	7.3	Ma
			4	7.1	Ly
			6	7.2	Bu
			7	6.9	Sp
			8	7.5	M
			10	7.3	Ly
			23	8.0	Ba
			24	8.2	S
			24	8.2	O
			24	8.4	M
			29	8.5	O
		2	3	8.6	O
123160	T Urs. Maj.	1	8	11.5	M
123307	R Virginis	1	7	6.4	E
123459	RS Urs. Maj.	1	8	9.2	M
			23	10.4	Ba
123961	S Urs. Maj.	12	28	8.5	E
		1	4	8.4	Ly
			8	8.2	M
			10	8.2	E
			22	7.8	E
			23	7.5	Ba
			24	7.6	S
134440	R Can. Ven.	1	2	7.7	E
141567	U Urs. Min.	12	8	8.0	Ba
			12	7.9	Ba
		1	24	8.0	Ba
		2	3	8.4	S
141954	S Bootis	1	2	12.2	E
142539	V Bootis	1	2	8.6	E
143227	R Bootis	1	2	9.0	E
151614	S Serpentis	1	2	12.5	E
151731	S Cor. Bor.	1	2	10.0	E
153378	S Urs. Min.	12	12	11.8	Ba
		1	4	11.9	Ly
			24	10.6	Ba
154428	R Cor. Bor.	1	2.9	6.8	E
			6.9	6.6	E
154440	V Cor. Bor.	1	2	8.0	E
154615	R Serpentis	1	2	12.5	E
160210	U Serpentis	1	2	11.9	E
161138	W Cor. Bor.	1	2	8.5	E
163172	R Urs. Min.	12	12	10.0	Ba
			26	10.4	R
		1	24	10.3	Ba
163266	R Draconis	12	12	11.8	Ba
		1	9	11.9	Cr
			10	12.0	Ly
			24	11.0	Ba
164715	S Herculis	1	3	10.0	E
171723	RS Herculis	12	8	9.5	Ba
175458	T Draconis	12	12	10.4	Ba
180565	W Draconis	12	12	9.9	Ba
		1	24	10.8	Ba
183308	X Ophiuchi	12	12	7.5	Ba
184243	RW Lyrae	12	8	11.8	Ba
			12	11.6	Ba
193449	R Cygni	12	12	12.1	Ba
193732	TT Cygni	12	26	8.4	R
194048	RT Cygni	12	12	8.9	Ba
			26	9.7	R
194348	TU Cygni	12	12	9.3	Ba
			26	10.0	R
194632	χ Cygni	12	12	8.0	Ba
			26	7.1	R
		1	10	5.9	E
			31	5.7	Ba

VARIABLE STAR OBSERVATIONS Jan.-Feb., 1916—Continued.

195116
S Sagittae

Mo.	Day	Est.	Obs.
12	26.6	5.9	R
	27.7	5.7	R
	31.6	6.4	R

195849
Z Cygni

Mo.	Day	Est.	Obs.
12	12	8.5	Ba
1	3	8.8	V
	24	9.1	M

200357
S Cygni

Mo.	Day	Est.	Obs.
12	26	10.4	R
1	8	10.2	M

200647
SV Cygni

Mo.	Day	Est.	Obs.
12	26	9.0	R
1	6	8.7	Cr
	7	9.2	Pi
	7	8.9	Cr
	10	9.3	Mu
	14	9.4	Cr
	24	9.1	M

200715 a
S Aquilae

Mo.	Day	Est.	Obs.
12	27	8.9	R

200715 b
RW Aquilae

Mo.	Day	Est.	Obs.
12	26	9.4	R
	27	9.4	R
	31	9.4	R

200747
RX Cygni

Mo.	Day	Est.	Obs.
1	6	8.3	Cr
	14	7.6	Cr

200916
R Sagittae

Mo.	Day	Est.	Obs.
12	27	9.1	R

200938
RS Cygni

Mo.	Day	Est.	Obs.
12	26	7.8	R
1	6	7.8	Pi
	24	8.5	M

201647
U Cygni

Mo.	Day	Est.	Obs.
12	26	7.0	R
1	4	7.1	Ly
	6	6.9	Cr
	7	6.8	Cr
	7	7.3	Pi
	9	7.0	Cr
	10	7.0	Ly
	10	6.7	Mu
	14	6.9	Cr
	24	6.8	M
2	4	7.3	S

202539
RW Cygni

Mo.	Day	Est.	Obs.
12	26	9.1	R
1	6	8.6	Pi
	24	8.4	M

202946
SZ Cygni

Mo.	Day	Est.	Obs.
12	11	9.3	Ba
	12	9.4	Ba
	26	10.6	R
	31	10.2	R
1	24	9.1	M
	24	9.0	Ba
	31	9.7	Ba

202954
ST Cygni

Mo.	Day	Est.	Obs.
1	7	11.9	Hu

203226
V Vulpeculae

Mo.	Day	Est.	Obs.
12	27	8.5	R

203847
V Cygni

Mo.	Day	Est.	Obs.
1	24	10.2	M

204318
V Delphini

Mo.	Day	Est.	Obs.
12	12	10.7	Ba

205923
R Vulpec.

Mo.	Day	Est.	Obs.
12	26	9.1	R

210116
RS Capric.

Mo.	Day	Est.	Obs.
12	27	8.6	R

210382
X Cephei

Mo.	Day	Est.	Obs.
1	24	11.8	Y

210868
T Cephei

Mo.	Day	Est.	Obs.
12	26	7.2	R
1	2	6.3	Ma
	24	6.7	S
	29	7.5	Nt
	31	6.9	Ba

213244
W Cygni

Mo.	Day	Est.	Obs.
12	26	7.0	R

213678
S Cephei

Mo.	Day	Est.	Obs.
1	31	9.3	Ba
2	3	9.8	S

213753
RU Cygni

Mo.	Day	Est.	Obs.
12	26	8.7	R
1	24	8.8	M

213843
SS Cygni

Mo.	Day	Est.	Obs.
12	8.5	11.9	Ba
	11.5	11.9	Ba
	12.5	11.9	Ba
	26.6	8.4	R
	27.6	8.6	R
	28.6	9.6	E
	31.6	8.6	R
1	2.5	11.6	Hu
	2.6	11.3	E
	3.5	11.5	E
	4.5	11.4	Ly
	5.5	11.6	E
	6.5	11.9	Cr
	6.5	12.0	Pi
	6.5	11.8	B

SS Cygni

Mo.	Day	Est.	Obs.
1	7.5	11.9	Cr
	7.5	12.0	Hu
	7.5	12.0	Pi
	8.6	12.0	M
	10.5	11.8	Ly
	10.5	11.7	E
	23.5	11.9	Ba
	24.5	12.0	M
	24.5	11.9	B
	24.5	11.9	Ba
	29.5	11.0	B
	31.5	8.5	Ba
2	4	9.9	S

213937
RV Cygni

Mo.	Day	Est.	Obs.
12	27	8.5	R
1	2	8.3	Ma
	7	8.0	Hu
	24	7.8	M

220714
RS Pegasi

Mo.	Day	Est.	Obs.
1	3	8.9	V
	7	9.3	O

222439
S Lacertae

Mo.	Day	Est.	Obs.
1	24	12.9	B
	24	11.8	Y

225120
S Aquarii

Mo.	Day	Est.	Obs.
12	12	8.6	Ba

225914
RW Pegasi

Mo.	Day	Est.	Obs.
12	12	9.7	Ba
	26	9.3	R
1	4	9.7	Mu
	5	10.0	V
	24	10.3	V
	27	9.7	M

230110
R Pegasi

Mo.	Day	Est.	Obs.
12	12	7.0	Ba
	27	7.2	R
	28	7.6	E
1	4	7.4	Mu
	6	8.1	O
	6	7.7	Pi
	15	7.2	Ma
	23	8.4	E
	24	8.1	Ba
	27	8.5	M
	29	7.2	Nt
	31	8.1	Ba

230759
V Cassiop.

Mo.	Day	Est.	Obs.
1	24	11.6	Y
	29	11.8	B

233335
ST Androm.

Mo.	Day	Est.	Obs.
1	2	10.6	Hu
	6	10.7	O
	24	10.5	Ba
	31	10.3	Ba
2	3	10.6	S

233815
R Aquarii

Mo.	Day	Est.	Obs.
12	27	9.9	R
	28	9.6	E

235350
R Cassiop.

Mo.	Day	Est.	Obs.
12	27	7.7	R
1	23	8.6	E
2	3	9.1	O

235525
Z Pegasi

Mo.	Day	Est.	Obs.
1	3	8.8	V
	7	8.5	O
	24	8.3	V
	31	8.3	Ba

No. of observations 439; No. of stars observed 127; No. of observers 19.

The following calculated dates of maxima cited from *The Companion to the Observatory* may be of interest:

March	1	090425	W Cancri
	6	023133	R Trianguli
	8	123961	S Ursae Majoris
	11	021143	W Andromedae
	12	001755	T Cassiopeiae

The variable 073508 U Can. Min. recently registered an unusually bright maximum, approximately 8.0 magnitude, which is brighter than any previously recorded maximum.

Mr. J. J. Crane of Sandwich, Mass., has recently completed a serviceable obserobservatory, and is making good progress in the observation of variables. Mr. D. B. Pickering plans to erect a dome on his house at E. Orange, N. J., which will greatly facilitate observing. Thanks are due these gentlemen for a good number of blue prints of the charts sent to the Secretary for distribution.

The following members contributed to this report:—Messrs. Bancroft, Bouton, Burbeck, Crane, Eaton, Hoge, Hunter, Lindsley, Mach, McAteer, Mundt, Nolte, Olcott, Pickering, Richter, Spinney, Vrooman, Miss Swartz and Miss Young.

William Tyler Olcott,
Corresponding Sec'y.

Norwich, Conn.
Feb. 10, 1916.

COMMUNICATIONS.

Does Astronomy Favor Peace? Men who believe and teach that the earth would be over-populated if it were not for war and pestilence forget that the earth is not standing still, and that sustenance sufficient for all increase in population may be in course of preparation, or that it is already prepared and only awaits discovery, just as coal was discovered. They also forget that all the energy wasted on war could be turned into other channels, and that any problems which may seem to stand in the way of a kindly harmony would solve themselves under new conditions.

Out in the evening sky shines Jupiter, the planet that made history, overturned creeds and "changed men's thoughts for all time," when Galileo discovered four of his moons and the phases of Mercury and Venus; and that planet will change men's thoughts again, because the size of his moons and the rapidity of their movements round him—into and out of his mighty shadow when they are eclipsed, their occultations when they pass behind him, their transits when they trail their dark eclipse-shadows across his surface as they totally eclipse the sun, all of which can be seen with a telescope only three inches in diameter—while he himself revolves round the sun, furnish the most striking illustration of the fact that one system revolves round another.

The revolution of Earth, Mars, Jupiter, Saturn, Uranus, and Neptune round the sun with their satellites revolving round them confirms the discovery that the sun and planets are moving toward a certain point in the sky.

The path in which the entire solar system is moving, will probably be found to be a very great orbit; and this wonderful journey on which we sail under sealed orders, together with the fact that the inclination of the earth's axis is diminishing and that the time when the earth is nearest the sun is making a complete circuit of the seasons, will very probably produce internal and external changes in the earth. We traverse new regions of space daily; and we know that people are restored to health by an ocean voyage which lasts only as long as it takes a ship, a tiny asteroid, to make an oscillation between the shores of the sea.

And who shall say what wonderful provisions may not come out of Nature and Nature's God, the kindly father of us all—not the cruel, mythical, sheep-sacrificing God of war and everlasting punishment—when in the centuries yet to come, the great population of the earth may see a spring-time in which the awakening of food-producing plants and latent powers in man will outshine the wonderful resurrection that occurs in our annual spring?

CHARLES GROSJEAN.

The Setting of Venus on October 27, 1914.—I was to be on duty with the spectrograph (the Bruce on the 40-inch) for the first half of the night.

Accordingly, since at sun-down the sky was clear with the exception of some filmy, hazy clouds, and whereas the work required that I be in the dome about six, I had an early supper. When in due time I reached the observatory, the sky was just bad enough to make it not worth while "opening up" the shutter. The clouds, extending all over the sky with here and there breaks or open spaces in them, were not so thick but what the brighter stars were visible through them. I went up into the dome and out upon the broad roof of the observatory building. There was a little of a north wind but it was not very cold and I was very comfortably dressed. Hearing the peculiar whisking of the wind through the almost leafless trees on the sloping bank of the lake to the south, I turned to look over the lake. The sound of the wind was ominous (it reminded one of much colder breezes to come), perhaps less agreeable than the softer rustles of summer, but there was an attractive mysteriousness about it which made it sound not at all unpleasant—perhaps the association of sitting around a warm fire while from the outside is heard the howling of the wind over the snow-covered ground.

A faint suggestion of a halo could be seen about the moon. The earth's satellite, quite high and a little past first quarter, cast a phosphorescent glow across the lake. Two or three lights dotted the dark opaque stretch of the opposite shore.

Low in the southwest where the sky was part clear and sunset tinted, and just below the heavy gilt-edged curtain of an extensive horizon cloud, Venus was shining quite gloriously. It occurred to me to watch Venus set. As the minutes went by, the orb sank lower and lower, growing gradually redder and dimmer. When very near the horizon and apparently just above the distant hills on the west shore, it went out for a moment. Then it appeared, and for an instant was somewhat brighter. Then becoming fainter it faded out again; then it reappeared and remained visible until just when it seemed to rest on the horizon and was low enough to be mistaken for a land-light, it vanished behind the hills.

Up and above to the left there was a very distinct halo around the moon. Just about the edge of the moon was a circular gleam of light due to the intervening veil of cloud. Well within the lunar halo, below and to the right, the planet Jupiter shone, now second in brightness only to the moon. Near the zenith was an open space. I went to the comet-seeker and swept over it a while.

CHARLES A. MANEY.

Alma College,
Alma Michigan. Jan. 30, 1916.

N. B. The above was taken from a diary.

COMET AND ASTEROID NOTES.

Elements and Ephemeris of Eros for 1917.—Enclosed are elements, constants and ephemeris of Eros for next opposition.

EPHEMERIS.

1917	α			δ			log r	log Δ
	h	m	s	°	′	″		
Jan. 20	13	41	49	—21	10	46	0.06668	9.80620
24	13	51	24	—23	21	55	0.06944	9.79986
28	14	1	3	—25	24	43	0.07234	9.79725
Feb. 1	14	10	19	—27	26	21	0.07546	9.79266
5	14	19	17	—29	24	10	0.07876	9.78794
9	14	27	56	—31	18	11	0.08222	9.78312
13	14	36	14	—33	8	17	0.08580	9.77803
17	14	44	3	—34	54	20	0.08954	9.77280
21	14	51	24	—36	36	20	0.09336	9.76735
25	14	58	9	—38	14	11	0.09728	9.76162
Mar. 1	15	4	15	—39	47	43	0.10126	9.75592
5	15	9	38	—41	17	12	0.10530	9.74996
9	15	14	6	—42	41	41	0.10942	9.74396
13	15	17	41	—44	2	2	0.11358	9.73783
17	15	20	14	—45	17	7	0.11772	9.73168
21	15	21	34	—46	26	9	0.12192	9.72570
25	15	21	50	—47	28	24	0.12610	9.72014
29	15	20	26	—48	24	25	0.13026	9.71435
Apr. 2	15	17	47	—49	10	58	0.13442	9.70940
6	15	13	52	—49	48	4	0.14854	9.70506
10	15	8	37	—50	13	51	0.14264	9.70155
14	15	2	20	—50	27	41	0.14668	9.69904
18	14	55	2	—50	27	30	0.15070	9.69779
22	14	47	6	—50	12	45	0.15466	9.69797
26	14	38	57	—49	43	46	0.15856	9.69971
30	14	30	50	—49	0	22	0.16240	9.70320
May 4	14	22	55	—48	3	16	0.16618	9.70849
8	14	16	15	—46	57	16	0.16988	9.71564
12	14	10	11	—45	41	31	0.17350	9.72454
16	14	5	13	—44	18	43	0.17708	9.73543
20	14	1	16	—42	53	7	0.18056	9.74757
24	13	58	28	—41	25	14	0.18396	9.76139
28	13	56	48	—39	58	7	0.18730	9.77655
June 1	13	56	9	—38	33	25	0.19054	9.79274
5	13	56	29	—37	12	23	0.19372	9.80984

CONTANTS.

$$x = r\,[9.99461] \sin(\ 34^\circ\ 3'\ 41'' + u)$$
$$y = r\,[9.94143] \sin(299\ \ 0\ \ 14\ \ + u)$$
$$z = r\,[9.70826] \sin(319\ \ 31\ \ 38\ \ + u)$$

ELEMENTS.

Epoch = April 26.50 G. M. T. 1917
$M = 74^\circ\ 8'\ 17''.43$
$\omega = 177\ \ 50\ \ 23\ .24$
$\Omega = 303\ \ 35\ \ 8\ .69$
$i = 10\ \ 49\ \ 39\ .51$
$\phi = 12\ \ 53\ \ 0\ .56$
$\mu = 2014''.830$
$\log a = 0.163850$
$\log q = 0.054280$

F. E. SEAGRAVE.

Comet 1915 *e* (Taylor).—*Bulletin* 599 of the Harvard College Observatory announces an unusual change in this comet according to a telegram received from the Yerkes Observatory as follows:

"Barnard finds Taylor's comet has double nucleus distance ten seconds position angle twenty-one degrees at seven hours thirty minutes Central Time February ninth magnitudes about fourteen and fifteen."

GENERAL NOTES.

Erratum.—On page 174, line 17, for "Menth's" read "Marth's".

Professor Paul Painlevé, of the department of mathematics in the University of Paris, is minister of education in the present French cabinet. (*The Am. Math. Monthly*).

The Bruce Gold Medal of the Astronomical Society of the Pacific has been awarded to Dr. George Ellery Hale, director of the Mount Wilson Solar Observatory, (*Science*, Feb. 11, 1916).

Mr. Charles A. Maney is at present engaged in research on Spectrographic Cosmogony at Alma College, Alma, Michigan, Astronomical publications will be appreciated.

Charles Le Morvan, assistant astronomer at the Paris Observatory, has received a grant of 4000 francs from the Bonaparte Fund of the Paris Academy of Sciences for the publication of a systematic and photographic map of the moon.

Dr. F. Henroteau, of the Brussels Observatory, has been appointed Visiting Assistant Astronomer in the Observatory of the University of Michigan, on salary provided by Mr. R. P. Lamont of Chicago. Since the outbreak of the European war Dr. Henroteau has been at the Stonyhurst College Observatory, at Blackburn, England. He is expected at Ann Arbor soon.

The Argentine National Observatory at Cordoba sent an expedition to Venezuela to observe the total eclipse of the sun on February 3. The expedition was under the charge of astronomer Chaudet and was equipped with two cameras for photographing the corona, two prismatic cameras for the flash and coronal spectrum, a small slit spectrograph and a photometer. It was expected to occupy a station in or near Tucacas.

A cablegram received at the Harvard College Observatory on February 9 announces that the Argentine expedition observed the total solar eclipse through thin clouds.

The Shape of the Earth.—The earth may be as rigid as steel, but steel is very far, indeed, from being a very rigid body. I have seen a bar of steel 1-inch in diameter behaving like putty when subjected to the quite insignificant strain of about 43 tons. A sphere of steel the size of the earth would be absolutely plastic to such cosmical forces as a planet is subjected to. Even at such small depths as these of our deeper mines, the rock behaves like a plastic substance; the roof sags, and the floor bulges under the weight of a few thousand feet of the earth's crust. So it is quite certain that the present shape of the earth is due to its *present* rate of rotation, not to the rate it had in some hypothetical past. The very fact that the oceans are not collected about the poles is sufficient proof of this. The portion of the earth which consists of free water conforms perfectly to the shape of the solid portion. In fact, the shape of the earth is the same as the shape of a globe of water, and rotating at the same rate, would be. [Mr. Wm. F. A. Ellison in the *English Mechanic and World of Science*, Jan. 21, 1916.]

The Mathematical Association of America is the name of a new organization of teachers of mathematics formed on December 30, 1915, at Columbus, Ohio. The object of this association, as expressed in its constitution, shall be to assist in promoting the interests of mathematics in America, especially in the collegiate field. There are two kinds of membership, personal and institutional. Any person who is interested in the field of collegiate mathematics and any institutions in which the Calculus is regularly taught shall be eligible to membership. The official journal of this association is *The American Mathematical Monthly*.

The Nantucket Maria Mitchell Association.—Miss Margaret Harwood, Radcliffe 1907, later at Harvard Observatory until June, 1912, and, by Annual Award, Fellow of the Nantucket Maria Mitchell Association, 1912-16, has been appointed for an indefinite term Fellow of the above named Association and Director of its Observatory. This year, which is "The Quadrennial" provided for in the Fellowship, Miss Harwood is studying at the University of California. Her new year at the Nantucket Observatory will begin June 15, 1916.

Many women teach astronomy successfully, but few openings exist for women to do research work, and a majority of the Fellowship Committee recommended Miss Harwood's permanent appointment, to insure to a woman in every way prepared, this unusual privilege, free from academic control. One member of the committee, while recognizing Miss Harwood's fitness, maintained that from the teacher's view point it seemed to curtail the opportunities for young women.

A special meeting of the Board of Managers was duly called and held in Boston, October 6, 1915. All correspondence on the subject and the votes of the Committee were carefully considered. As all money collected for this fund is recorded as primarily intended for research, the following resolution was unanimously adopted:

Resolved: "That in recognition of Margaret Harwood's exceptional qualifications and her fitness for the work on Nantucket, she be made Astronomical Fellow of the Association for an indefinite term and Director of its Observatory."

A Five Hundred Dollar Fellowship to be known as the Maria Mitchell Memorial Fellowship at Harvard Observatory is assured by special donation for three more years, viz: 1916-19. This Fellowship for 1916-17 has been awarded to Miss Susan Raymond, who is the present Nantucket Fellow (1915-16).

The Harvard Fellowship will be open for applications for the years 1917-18 and 1918-19, notices of which will be duly issued.

COMMITTEE
ANNIE J. CANNON, A. M., Curator of Astronomical Photographs, Harvard College Observatory.
PROF. MARY W. WHITNEY, Director Emeritus of Vassar College Observatory.
PROF. EDWARD C. PICKERING, Sc. D., Director of Harvard College Observatory.
PROF. ANNE S. YOUNG, PH. D., Director of Mt. Holyoke Observatory.
ELIZABETH R. COFFIN, A. B., Vassar College, 1870, Nantucket, Mass.
FLORENCE M. CUSHING, A. B., Vassar College, 1874, Boston.
LYDIA S. HINCHMAN, *Secretary*, 3635 Chestnut St., Philadelphia.

Stars and the War is the title of an interesting paper by Camille Flammarion published in *L' Astronomie* for March, 1915. A translation of parts of this paper by Mr. Allan B. Burbeck follows.

The question to be determined whether the stars have any influence whatever on mankind is far from being agreed upon by a great many cultivated minds. It must be acknowledged that certain coincidences appear to support this old belief, found in the books of olden times, from the Iliad and the Enead up to the present.

The frightful war now turned loose upon Europe is found to be accompanied by astronomical and geological phenomena which recall to the memory many notions that were believed through antiquity and the middle ages, but which we had considered obsolete for a long time.

In turning over the pages, yellow with age, of the works of the fifteenth and sixteenth centuries, such as le Livre des Prodiges by Conrad Lycosthènes, the Chroniques de Nuremberg, the works of Ambroise Parè or Julius Obsequeus, one sees a series of fantastic figures representing eclipses, comets, stones that fall from the sky, earthquakes, floods, tempests and hail storms, solar and lunar halos, animal and yegetable monsters, crosses; all associated with wars and massacres, and considered as signs of heavenly wrath and manifestations of divine justice punishing wicked man.

A total eclipse of the sun occurred on August 21, 1914 visible throughout entire Europe and Asia, the zone of totality crossing Russia. I received a large number of letters in July connecting this celestial phenomenon with the thought of a war, and in this review was printed one of these letters sent me on July 6 by M. Constantin Boboritsky, member of the society from the center of Russia.

A comet which will hold the name of "the Comet of War" has been visible the entire year in the sky. Discovered in December 1913 by Delavan at the La Plata Observatory, it is still visible at this time and will be for five years. This prolonged cometary apparition is not yet witnessed. Formerly, it would have been inferred that we shall have a new war of seven years duration. Everyone was able to see this vaporish star moving slowly below Ursa Major last September and October. Without being as striking as large comets, which stretch out their long tails across the constellations, this distant apparition was not any less remarkable.

A third celestial sign is added to the two preceding ones, the passage of Mercury across the face of the sun on November 7 last.

Have shooting stars appeared? Have stones fallen from the sky? Yes. Nothing is lacking from the series. In addition to meteors and bolides which are not very rare, a very remarkable stone fell from celestial space in England last October 13. It was a sort of a broken pyramid, measuring twenty seven centimeters in length and weighing sixteen kilograms. This uranolith was composed principally of silica, iron, magnesia and nickel.

Is this all? No. A dreadful earthquake shook Italy in the country surrounding Rome on January 13, 1915; if it was not a seismic shock of the first order, from the geological point of view, it was found to have been of the greatest destructive intensity, ninety per cent of the inhabitants of Avezzano killed, ninety four per cent at Cose, ninety nine per cent at Lapolle: thirty thousand deaths in that district.

Is this all? No. Endless rain storms, overflowings of the Seine, the Marne, the Oise, the Aisne, the Saone, the Thames and the Rhine floods.

There are, it seems, a sufficient number of atmospheric, astronomical, and geological manifestations associated with this present war. A careful examination of the year will bring forth others also. For an example, on the eighth of last June, descending the Eiffel Tower, I was surprised by a violent tempest, I found at the base—hail and snow, and we were able to make snow balls as in winter. That day, the thermometer went down fifty degrees at Paris, and the average temperature of that day was nine degrees less than that of the eighth or fifteenth of February. What fantastic anomalies!

On July 21, from 9:15 to 9:50 a. m. at Paris, the sky was so obscured that it was necessary to light the lamps and it was impossible to read the newspapers. Heavy and suffocating atmosphere, then a heavy downpour of dark colored water leaving spots of soot.

And if we do not speak of the tri-colored star conspicuous by so much testimony, we will return to it although it may be only an optical effect enlarged by popular imagination.

This mass of facts, we are able to explain easily, in our age of positive analysis, but such coincidences would have struck the imagination in the ages of credulity and ignorance, at the time when it is supposed that Jupiter hurled the thunder bolts, Neptune agitated the waves and Vulcan shook the foundations of the earth.

However these happenings are absolutely accidental, the stars do not govern the actions of humanity and those who say that our globe is at this time under the warlike influence of the planet Mars are poorly founded in their incoherent assertions. Mars is not responsible for the calamities of barbarous mankind for it is at present located at its greatest distance from us. But these curious coincidences may be truly interesting to note.

Humanity has always liked to blame its faults and its mistakes on influences of which it may be the victim. It would me more just if it took the blame upon itself and should resolve finally of becoming sensible.

The Sun's Orbit.—We have known for a century that the sun is moving with reference to the average of the nearer stars and are now accustomed to speak of the "Sun's Way", or point toward which it is moving, as being between the star groups of Hercules and Lyra, probably within 10° or less of Vega (α Lyrae). Whether it is moving in a straight line or in an arc of an enormous circle, or some other curve, it has been impossible to determine; altho Alcyone, and later Canopus, have, on wholly insufficient grounds, been assigned the place of "central sun." Recently Professor Oppenheim of Vienna, employing harmonic analysis upon the apparent motions (proper and radial) of 233 helium stars (class B), with an approximation in regard to their parallaxes, has obtained some results which in his judgment seem to indicate the reality of motion, not only of the sun but of the stars, around one ideal center. The sun as viewed from this center appears in R. A. 203° 55′, Decl. —34° 09′. The corresponding apex of the solar motion is at R. A. 266°, Decl. +34° 37′. The discussion of the results is given in the *Astronomische Nachrichten* No. 4822.

Actual Time of Signals from the U.S. Naval Observatory, January, 1916.

Day	Time of signals Noon h	m	s	Error	Time of signals 10:00 p.m. h	m	s	Error	
1	12	0	0.01	+.01	10	0	0.03	+.03	Holiday
2	12	0	0.03	+.03	10	0	0.03	+.03	Sunday
3	12	0	0.01	+.01	10	0	0.00	.00	
4	11	59	59.98	—.02	9	59	59.97	—.03	
5	11	59	59.96	—.04	9	59	59.95	—.05	
6	11	59	59.94	—.06	9	59	59.93	—.07	
7	11	59	59.93	—.07	9	59	59.93	—.07	
8	12	0	0.00	.00	10	0	0.00	.00	
9	12	0	0.01	+.01	9	59	59.96	—.04	Sunday
10	12	0	0.01	+.01	10	0	0.01	+.01	
11	12	0	0.01	+.01	10	0	0.03	+.03	
12	12	0	0.04	+.04	10	0	0.04	+.04	
13	12	0	0.05	+.05	10	0	0.05	+.05	
14	12	0	0.01	+.01	10	0	0.01	+.01	
15	12	0	0.04	+.04	10	9	0.04	+.04	
16	12	0	0.05	+.05	10	0	0.05	+.05	Sunday
17	12	0	0.06	+.06	10	0	0.06	+.06	
18	12	0	0.00	.00	9	59	59.99	—.01	
19	12	0	0.00	.00	9	59	59.99	—.01	
20	11	59	59.98	—.02	9	59	59.99	—.01	
21	12	0	0.00	.00	9	59	59.99	—.01	
22	12	0	0.01	+.01	10	0	0.00	.00	
23	12	0	0.02	+.02	10	0	0.00	.00	Sunday
24	12	0	0.01	+.01	9	59	59.99	—.01	
25	11	59	59.99	—.01	9	59	59.98	—.02	
26	11	59	59.99	—.01	9	59	59.94	—.06	
27	11	59	59.91	—.09	9	59	59.92	—.08	
28	11	59	59.92	—.08	9	59	59.92	—.08	
29	11	59	59.96	—.04	9	59	59.96	—.04	
30	11	59	59.95	—.05	8	59	59.94	—.06	Sunday
31	11	59	59.93	—.07	9	59	59.94	—.06	

Maximum error: Jan. 27, —0.09 sec.

Constant to be added to above errors to give error of radio signals from

Arlington +0.02 sec.
Key West +0.27

J. A. Hoogewerff,
Captain U. S. Navy
Superintendent.

U. S. Naval Observatory,
Washington, D. C.
Feb. 4, 1915.

Analytic Mechanics, by John A. Miller, Professor of Mathematics, and Scott B. Lilly, Assistant Professor of Engineering, Swarthmore College. *Pages XV +297. D. C. Heath and Co. 1915.*—This excellent work will be welcomed by many teachers who are looking for a text in theoretical mechanics for advanced undergraduates, which is both rigorous and teachable. It is not intended to be a technical book primarily for engineering schools. Only those principles are treated which are alike fundamental to the study of theoretical physics, celestial mechanics and engineering. However, the illustrative exercises are chosen largely from the engineering field. Many of them are problems from real structures and real machines and, therefore, cannot fail to prove interesting and attractive to the student.

In several respects it is an unusually good textbook. The statements of the theorems and principles are remarkably clear. The proofs are rigorous and the mathematical reasoning is invariably preceded by a careful statement of the assumptions made. Moreover, frequent "remarks" to students are inserted which not only serve as hints in attacking problems, but call attention also to the applicability and to the limitations of fundamental methods.

Another commendable feature in a book of this grade is the fact that the authors have chosen the older methods of treatment, such as the resolution of forces, etc., thus keeping the student close to the physics of the problem. No knowledge of vector analysis is assumed and no vector methods are developed, except the simple ideas of addition, subtraction and resolution which are found in elementary textbooks of physics.

Some physicists will, no doubt, object to the strict adherence to the method of resolution of forces along the rectangular-coördinate directions because it complicates the mathematics in some places, but the authors are perhaps right in thinking this the best way to keep the undergraduate student's feet on the ground.

It is distinctly stated in the preface that one purpose of the work is to develop facility in the application of mathematics to physics. Consequently the book is mathematical, with only brief discussions of results. In the derivation of formulae the theorems of first-year calculus are freely used, but no knowledge of differential equations is assumed.

The subject matter is chosen as follows. Ten pages are devoted to the Compositon and Resolution of Forces Acting on a Particle; sixteen pages to Forces Acting on a Rigid Body; five pages to Vectors; sixteen pages to the Statics of a Rigid Body; nineteen pages to the Center of Gravity; eleven pages to Static Friction; nine pages to Flexible Cords; twenty-nine pages to the Kinetics of a Particle; seventeen pages to the Motion of a Particle in a Plane Curve; thirteen pages to Work and Energy; nine pages to Constrained Motion; eight pages to Impulse (Collision of Spheres); eighteen pages to Moment of Inertia; twenty six pages to the Dynamics of a Rigid Body; and eighteen pages to Kinetic Friction.

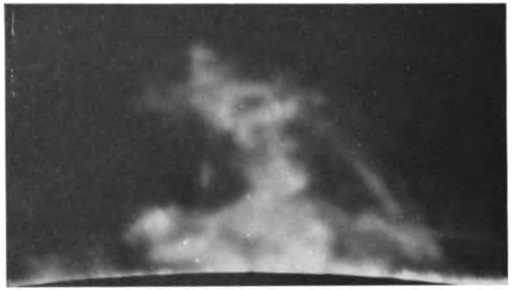
Only the gravitational system of units is used and, except in the discussion of moment of Inertia, W/g is written instead of mass. Problems are grouped at the end of each chapter and the answers are given.

Mechanically, the book is very attractive and it is of convenient size for a textbook. The type is good and the diagrams exceptionally clear.

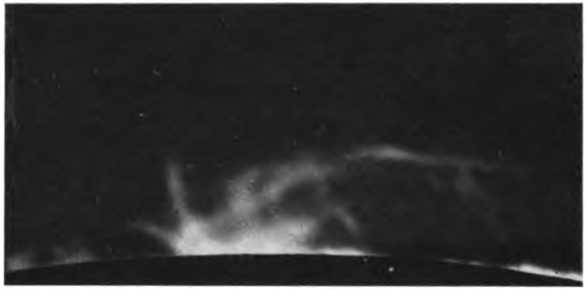
J. W. HORNBECK.

Carleton College.
Northfield, Minn.

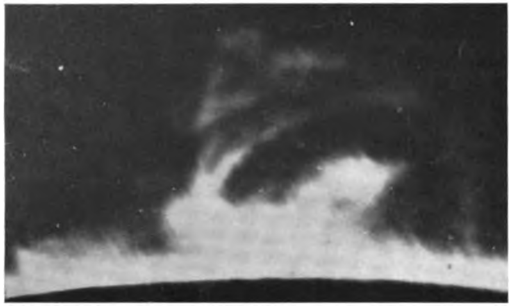
PLATE VIII



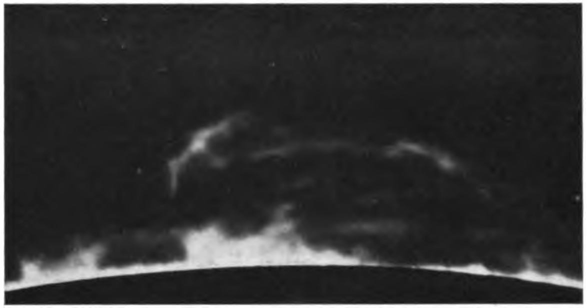
Time 4^{h} 7^{m} G.M.T.



Time 5^{h} 26^{m} G.M.T.



Time 4^{h} $52^{m}5$ G.M.T.



Time 7^{h} 3^{m} G.M.T.

The Solar Prominence of January 7, 1916
Photographed by O. J. Lee at Yerkes Observatory.
Scale: Diameter of Sun = 465 mm.

Popular Astronomy No. 234.

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Vol. XXIV, No. 4. APRIL, 1916. Whole No. 234

THE SOLAR PROMINENCE OF JANUARY 7, 1916.

OLIVER J. LEE.

A series of eleven photographs of this prominence was obtained with the Rumford spectroheliograph between $10^h 7^m$ a. m. and $1^h 15^m$ p. m. January 7, 1916. All were taken with light from the center of the H line of calcium. The disturbance took place over an arc of 17 degrees or 207,000 km along a meridian between points having position angles 56° and 73°. The center of the disturbance was at P. A. 65°.

In the first photograph taken at G. M. T. $4^h 7^m$ (Plate VIII) the denser masses of gas are evidently falling toward the south while the more rare portions retain their position and combine with the northward streamers to form the faint arch shown at G. M. T. $4^h 52^m.5$. At this time a new eruption is also shown projected up through the base of the first column but at a widely different angle, being inclined only about 40° to the tangent to the limb at its base. At G. M. T. $5^h 26^m$ the point of this eruption has travelled through a distance of 85,000 km at a rate of 42 km per second and at an elevation of 35,000 km from the surface of the sun. At G. M. T. $7^h 3^m$ the higher lying masses have become detached from the lower and are dissipating while drifting outward and toward the south.

Throughout the development of the prominence there is evidence of a moderate north wind in this region so that the low angle eruption shown in the second and third photographs, taking place against the wind, indicates that a tremendous expulsive force has operated. Another photograph taken the next day January 8 at G. M. T. $5^h 3^m$ through a very hazy sky shows low faint prominences at the seat of the previous day's activity.

Neither the flocculus plate of January 7 nor that of the next day shows any indication of disturbance in this region and cloudy weather on many succeeding days prevented observations of the effected area in better projection.

THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

[*Continued from page 162.*]

In the bitter quarrel which later followed between Scheiner and Galileo, both claiming the honor of the discovery of the spots, one looks in vain for the name of Fabricius. After finishing the unpleasant literature of this quarrel one realizes that he has not been concerned so much with the record of the actual events, as with a bitter strife in which the personal element predominates more than one would wish. To judge hastily one might well believe that the two principals were both ignorant of the work of Fabricius. But this seems hardly possible. Berthold maintains that both Galileo and Scheiner must have intentionally suppressed the name of Fabricius. It has been remarked that the Book Catalogue of the Fair came into the hands of all the learned men of the day, and the title of the *Narratio* would have been too attractive for either of them to have overlooked it. We recall also in passing, the *Prognosticon Astrologicum* for 1615, which contains information concerning the first observation of the solar spots, and particularly specifies Johann Fabricius as the first observer, while Apelles is only mentioned afterwards. However, it is possible that these may have been overlooked. But there is other evidence which would seem to prove unquestionably that neither Scheiner nor Galileo could have been ignorant of the name or discovery of Fabricius.

We first mention the *Mundus Jovialis* of Simon Mayr which appeared in 1614. This book is mentioned by Galileo in the *Saggiatore*,* and by Scheiner in the *Rosa Ursina*;† and we recall that Mayr refers to the two Fabricii as the first discoverers and observers of the solar spots. Secondly, we have the *Ephemerides Novae Motuum Coelestium* for the year 1617, by Kepler, published at Linz in 1618. And indeed one cannot well believe that either Galileo or Scheiner could have been ignorant of it. Kepler writes in the *Responsio ad Interpellationes Davidis Fabricii*:*

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* *Gal. Op.* 6, 215.

† Lib. I. p. 28, and Lib. II. p. 741.

> ......that the sun-spots were seen by your son, long before Apelles, if you are satisfied; and these proofs I have testified to many people at Prague, and I testify even now.

In addition to this, it seems that Scheiner was actually in correspondence with David Fabricius. The *Calendarium Historicum* contains the statement:†

> 1612, Scheiner, a Jesuit writes on the 29th day of October, (which was the evening of the lunar eclipse), all that 29th day the sky was very clear.

There can be no doubt that Fabricius' observations and the pamphlet that he published concerning them were known in Rome by the Jesuits and other friends of Scheiner. Kepler writes to Maelcote on the 18th of July 1613, describing his methods of observing the spots and mentions:‡

> A certain Fabricius of Wittenberg.......who published a book about this thing in June 1611, whom a certain man from Agusta [Augsburg] followed, either anonymously or with the assumed name of Apelles.

From this evidence, the assertion that both Galileo and Scheiner knew of Fabricius and the *Narratio*, certainly seems justified; but whether the suppression of Fabricius' name was intentional, as is maintained by Berthold, or whether Galileo and Scheiner were so occupied with their own affairs that Fabricius and his *Narratio* were immediately forgotten, is not apparent. The former is certainly possible, but the latter explanation seems the more probable.

Evidently the *Narratio* was not well known even in Germany, for it is mentioned only occasionally. There is but one notice of it during the seventeenth century, (quoted above). However, it became better known after the beginning of the eighteenth, for we now find several references to it. One in 1709;¶ another in the portion of Kepler's correspondence published by Hanchius in 1718.|| But the credit for completely resurrecting the *Narratio* from the dust of the library belongs to Christian Wolff, who, recovering and reading the pam-

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* *Kepleri Opera Omnia*, **2**, 785.

† *Astronomische Nachrichten*, **31**, 133.

‡ *Gal. Op.* **11**, 537.

¶ Jo. Bernardi Widiburgii *Dissertatio de maculis solaribus*...Helmstadtii, 1709.

|| *Joannis Kepleri aliorumque epistolæ mutuae.* Lipsiae, 1718. p. 557.

phlet, placed the author in his rightful position. In his *Vernünfftige Gedancken von den Würckungen der Natur,*[*] we find the following statement concerning Fabricius:

> After Galileo with his telescope had discovered many wonderful things, which he announced with his Nuncio Sidereo in 1610, among which were the satellites of Jupiter, and the innumerable hosts of stars, invisible to the naked eye, Johann Fabricius, the son of the celebrated astronomer David Fabricius, was aroused to observe the heavens with the telescope himself. With this object he brought one with him from Holland, and while he was sojourning with his father in East Friesland was desirous of observing the sun, and was fortunate in at once seeing spots on it, which he also showed to his father. He applied himself with all energy to this, so that he confirmed by many observations that which he had noticed in the first spots perceived in the sun; and continued observing from the beginning of the year up to the first of June; at which time the observations were sent to the press at Wittenberg at which place they were published in the same year. In this same year the celebrated Jesuit, Christoph Scheiner saw spots in the sun, as in the month of May he was examining the sun with his telescope for another purpose; which observations were published by Mark Welser under the title *Apelles post Tabulam,* because Theodore Busaeus, the provincial of the Jesuits, hesitated to give [Scheiner] permission to publish this under his own name. Through this Galileo was aroused so that in 1612 he at once observed spots on the sun, and afterward published an important tract concerning them.

While perhaps Wolff's remarks concerning Galileo and Scheiner are not altogether correct, this mention of Fabricius and his pamphlet served to attract attention to him, and to bring his name before the astronomical public.

There is no mention of the *Narratio* or of its author in any biographic or bibliographic repertory published previous to Weidler. He refers to it in his *History of Astronomy,* published in 1741 in the following words:[†]

> It is not to be kept silent that at about the same time as Scheiner, Johann Fabricius saw spots on the sun here at Vitemberg. He brought with him a new telescope from Batavia, and having turned it toward the sun, he saw spots; which he subsequently observed more diligently, examining their motions. He published at Wittemberg 1611 idib. Juni 4 narrationem de maculis in sole observatis......

Naturally Weidler inserted Fabricius' pamphlet in his *Astronomical Bibliography,*[‡] and thus being included in the materials proper of the history of the science it was mentioned by Montucla.[¶] In this way it became known to De la Lande, who gives a short synopsis of the few pages that are concerned with the solar spots.[||] Thus the knowledge of it has come down to us at the present time.

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[*] Halle in Magdeburg, 1723.

[†] Jo. Friderici Weidleri, *Historia Astronomia,*......Vitembergae, 1741.

[‡] Jo. Friderici Weidleri, *Bibliographia Astronomica,*...... Wittenbergae, 1755.

[¶] *Histoire des Mathematiques,* Paris, 1758. **2**, 311

[||] *Histoire de l'Academie Royale des Science*; Paris 1778. p. 395. Also in his *Astronomie*; Paris, 1792. **3**, 278, According to Berthold* there are but seven copies of the *Narratio* still in existence. These are in various libraries in continental Europe.

CHRISTOPHER SCHEINER AND THE LETTERS ON THE SOLAR SPOTS.

Christopher Scheiner was born in Walda, in Swabia in 1573. Early designed for the priesthood, he attended the Jesuit Latin School at Augsburg, then continuing his studies at the Jesuit College at Lansberg, he entered the order in 1595. Scheiner was then sent to the Hochschule at Ingolstadt where he applied himself to the study of the mathematical sciences and soon obtained the Master's degree. After obtaining this, he was sent in 1603 to Dillingen to assist with the teaching at the Jesuit Academy at that place. While Scheiner was at Dillingen he invented an instrument which alone would have been sufficient to insure his name to posterity. This instrument was the well-known pantograph. Upon leaving Dillingen, Scheiner returned to the Hochschule at Ingolstadt to continue his theological studies. In 1610 he was appointed Professor of Mathematics and Hebrew at the University of Ingolstadt. He remained at Ingolstadt for six years, observing the spots on the sun and devoting his time to scientific investigations. Leaving Ingolstadt, Scheiner went to Innsbruk and in the following year entered the priesthood. In 1620 he became Professor of Mathematics in the Jesuit College at Freiburg in Breisgau. Three years later Scheiner was named as Superior of the proposed Jesuit College at Neisse in Silesia, and a short time later became Rector. Scheiner went to Rome in connection with the affairs of this college in 1624, remaining there nine years. It was during his stay in Rome that Scheiner published his great book, the *Rosa Ursina*. Recalled by the Emperor Ferdinand II, Scheiner went to Vienna where he remained until 1639. From Vienna he returned to Neisse where he died in 1650.

Scheiner's announcement of his first observations was made in his first letter to Mark Welser. These letters to Welser, it will be remembered were signed with the assumed name, "Apelles Latens Post Tabulam." The reason for the anonymous publication is given by "Apelles" himself, namely, that the provincial of the Order would only permit the announcement of the discovery when made under a fictitious name.†

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* *Op. Cit.* p. 23.

† It is related that when Scheiner had communicated his discovery to Theodore Busaeus, the provincial, the latter refused to credit his assertions, "I have read my Aristotle from end to end many times", he remarked to Scheiner, "and I can assure you that I have never found in it anything similar to what you mention. Go, my son, calm yourself, and be assured that what you take for spots on the sun are the faults of your glasses or your eyes." (Montucla, *Histoire des Mathematiques.* 2, 312.)

In the first letter which is dated the 12th of November 1611, Apelles writes:*

> About seven or eight months ago (ante menses septem, octo circiter), I, together with a friend of mine, directed toward the sun an optic tube, which magnified about six or eight hundred times in area, to compare its [the sun's] apparent size with the moon, and we found them both to be the same. And while we were intent on this matter, we noticed certain black spots like darkish drops on the sun; but at that time our examination was not carefully made, thinking it to be a matter of no importance we postponed observations until another time. And thus we returned to this matter last month, October, and we found on the sun, apparently, spots, about as you see them pictured. Since this thing was hardly to be believed, we doubted at first whether it was not some fault of the eyes or of the tube, or of the atmosphere. Therefore we availed ourselves of the eyes of many peple, who all without exception saw the same things in the same place and in the same number. We concluded therefore, that the fault was not in the eyes, for how could it happen that the eyes of so many people should suffer from a similar affliction, which on certain days should change for another.

Scheiner continues, discusssing the impossibility of the spots being in the eyes of the observer, or in the telescope. Eight different telescopes were used and all showed the same spots in the same arrangement; revolving the telescope on its axis did not change the positions of the spots and this showed that they were not caused by it. From the lack of parallax it was concluded that the spots were not in the atmosphere of the earth, and since they are evidently real bodies of some sort they must be in the sun or in the heavens around it. If the spots are in the sun, it indicates that the sun rotates (for the spots move) and hence the spots should reappear; but since this does not happen, the sun does not rotate. Therefore the conclusion is that the spots are not in the sun, but are bodies (stellae) which come between us and the sun, and hence circulate around it. The appearance of individual spots is described (accompanied by drawings), and the letter concludes with a rather detailed account of the various methods of observing the spots. In this letter, Scheiner clearly shows the influence of the prevailing opinions of the time regarding the purity of "the Eye of the World", and of the admonitions of Busaeus. He retained his belief that the spots were planetary bodies circulating around the sun for many years, only relinquishing it when forced to do so by the evidence of his own observations.

In the second letter,† dated 19th of December 1611, Apelles describes a supposed inferior conjunction of Venus. He calculated according to the ephemeris of Magini, that Venus would be at inferior conjunction on December 11th, transiting the sun's disk as a black spot about 3′ in diameter, with a motion opposite to that of the spots. According to the calculation the transit should begin on the night of December 11th, continuing until the afternoon of the 13th. The 12th was entirely cloudy, but the next day dawned bright and clear; Venus, however, failed to make the expected appearance. Apelles thereupon concluded that Venus was on the other side of the sun, and thence dared to propose, contrary to the accepted Ptolemaic theory, that Venus revolved around the sun. The letter, which is short, has to do with the spots only in that Apelles argues from analogy to these that Venus revolved around the sun.

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* *Gal. Op.* **5**, 25.

† *Gal. Op.* **5**, 28.

In the third letter,* dated the 26th of December in the same year, Apelles discusses in more detail the observations which he had made up to date, and speaks with more assurance. He asserts that the spots are not in the sun; they require about fifteen days to transit the disk, and hence should reappear after an equal interval, but since they fail to do this they cannot be in the sun, "Impossibile itaque est, ut ulla Soli insit. Ubi ergo?" The spots are not in the atmosphere, nor in the region of the moon, nor of Venus, nor of Mercury, therefore they must be near the sun. Since they are not clouds or comets, it remains that they are bodies (stellae) which are solid and opaque. He explains the changes of shape and figure near the sun's edge as due to phases like the moon. He states that the spots are not far distant from the sun, they are of sufficient size or they would be swallowed up by irradiation, also they are very opaque and thick. They are compared to the satellites of Jupiter in that they surround the sun as the satellites do their primary. The letter concludes with the statement that between the sun and Mercury there ought to be a number of planets, and consequently we would see them when passing between the earth and the sun.

Accompanying the three letters is a series of drawings showing the appearance of the sun and spots from the 21st of October to the 14th of December 1611. (Plate IX).

All three of these letters were published by Welser at Augsburg, under the title *TRES EPISTOLAE DE MACVLIS SOLARIBVS. Scriptae ad MARCVM VELSERVM. AVGVSTAE VIND. II. VIRVM PRAEFECT......ANNO M. DC. XII. Non. Ian.* (Plate X). The book appeared on the 5th of January 1612. On the following day Welser forwarded a copy to Galileo with this letter:†

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* *Gal. Op.* **5**, 28.

† *Gal. Op.* **11**, 257.

> "The Kingdom of Heaven suffers violence, and violent people are destroying it." You were the first to scale the height and carried off the mural crown. After you others follow with greater courage, because they know that it would show cowardice not to second such happy and honorable enterprise. Now that you have once broken the ice, see what this friend of mine has risked; and, if as I believe, it will not be entirely new to you, I am hoping that you will be pleased to see that also on this side of the mountains there are not lacking those to follow in your footsteps.

Apparently there was some delay in the transmission of the book. Prince Cesi mentions it for the first time on March 3, 1612.* Galileo at this time was seriously ill, and consequently did not reply with his usual promptness, so that Welser wrote again on the 23rd of March,† urging a reply.

In the meantime, and certainly before receiving the copy of the *Tres Epistolae*, Galileo had referred to the solar spots, questioning their nature as already quoted (page 89) in the *Discorso*. The publication of this was sanctioned by the Holy Office on March 5th, and it finally appeared during the latter part of the month of May.

To the *Tres Epistolae* of Apelles, Galileo replied with two letters addressed to Welser, giving the details of his observations and explaining his theory of the spots.

In the first letter,‡ dated May 4, 1612, Galileo gives his reasons for not making an earlier announcement of the discovery of the spots; as already quoted, these are, his uncertainty of the nature of the spots, and the fear of attracting the wrath and enmity of the Peripatetics. The observations made during eighteen months have convinced him that the spots are real and not the fault of the eyes or of the glasses. The movement of the spots is from east to west and from south to north (the opposite was claimed by Apelles); that is, similar to the motion of Mercury and Venus at inferior conjunction and around the sun. The absence of parallax indicates that the spots are not near to the earth, but are far distant from it, and hence near to the sun. The spots are not exterior to the sun, as was held by Apelles. They are not solid bodies like the moon and the other planets, but are less solid and less dense; their appearance and behaviour resembling more that of clouds passing between us and the sun. Apelles believed that it could be proved by a comparison of the spots with Venus that the latter and Mercury revolved around the sun. Galileo expresses surprise that Apelles does not know of the discovery of the phases of Venus two years before, or that if he is aware of it, why he does not make use of this discovery which no longer permits any doubt of, but

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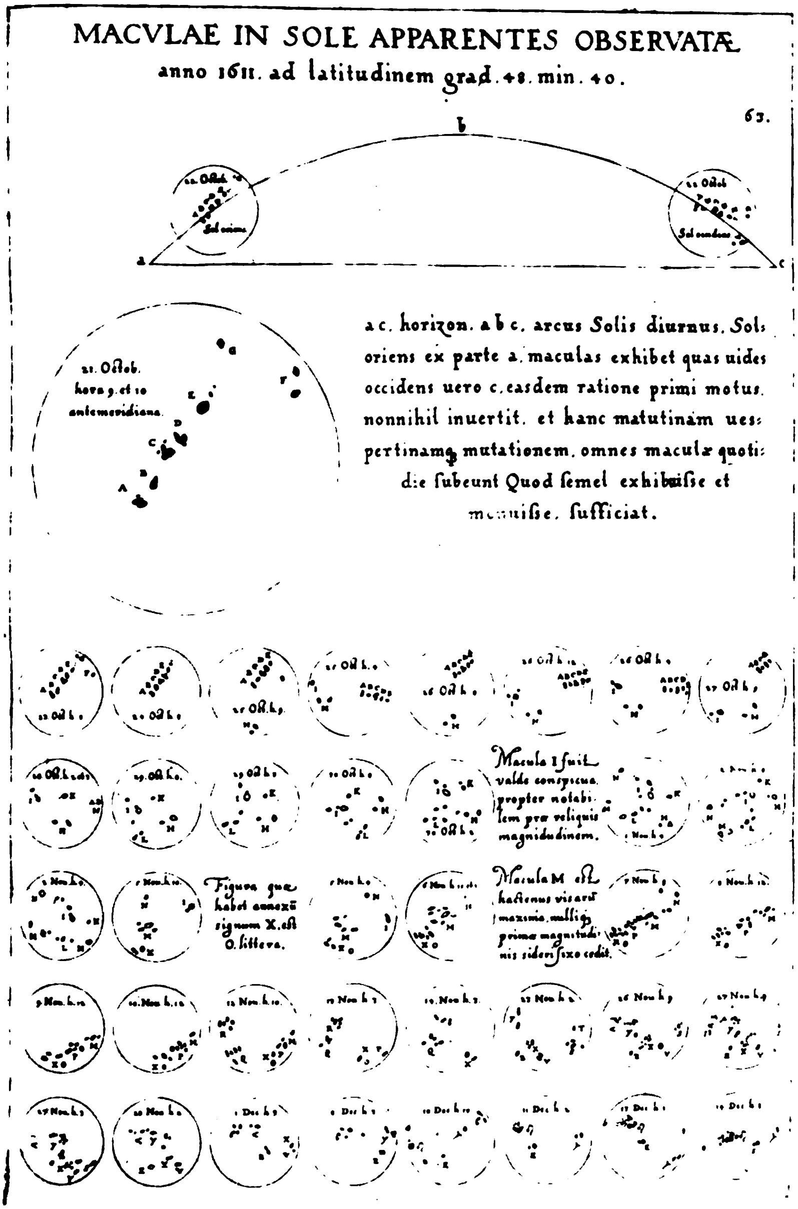
* *Gal. Op.* **11**, 280.
† *Gal. Op.* **11**, 289.
‡ *Gal. Op.* **5**, 94.

PLATE IX



MACVLAE IN SOLE APPARENTES OBSERVATÆ
anno 1611. ad latitudinem grad. 48. min. 40.

63.

ac. horizon. abc. arcus Solis diurnus. Sol oriens ex parte a. maculas exhibet quas uides occidens uero c. easdem ratione primi motus nonnihil inuertit. et hanc matutinam ueſpertinamq; mutationem. omnes maculæ quotidie ſubeunt Quod ſemel exhibuiſſe et monuiſſe, ſufficiat.

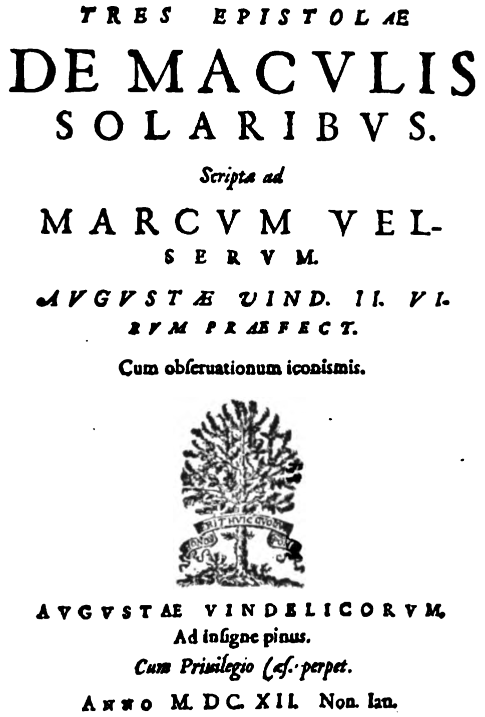
Macula I fuit valde conſpicua propter notabilem præ reliquis magnitudinem.

Figura quæ habet annexū signum X. eſt O. littera.

Macula M eſt hactenus viſarū maxima. nulliq; primæ magnitudinis ſideri fixo cedit.

Drawings of Sun and Spots accompanying the *Tres Epistolae*, as reproduced in the *Rosa Ursina*.

PLATE X



TRES EPISTOLÆ

DE MACVLIS
SOLARIBVS.

Scripta ad

MARCVM VELSERVM.

AVGVSTÆ VIND. II. VIRVM PRAEFECT.

Cum obſeruationum iconiſmis.

AVGVSTAE VINDELICORVM.
Ad inſigne pinus.
Cum Priuilegio Cæſ. perpet.
ANNO M. DC. XII. Non. Ian.

REDUCED FAC-SIMILE TITLE PAGE OF *Tres Epistolae*.

absolutely demonstrates the revolution of Venus around the sun, in accordance with the views of Pythagoras and Copernicus.

Galileo then discusses the opinions expressed by Apelles in his third letter. He states that the spots are not permanent, for some of them disappear while still on the sun's disk. The changes in the velocity of the spots at different points on the disk is explained as a result of the spots being attached to the body of the sun; for if the spots were far distant from it the differences in the velocities would then be imperceptible to our senses. Galileo expresses the need of accurate observations of this velocity in order to determine definitely the positions of the spots.

Concerning the assertions of Apelles that the spots are not clouds or comets, Galileo is not certain, and remarks that the material of which the spots are composed may be unknown to us and hence we can form no conclusion as to what it is:

> "I am quite certain that the material of which the spots are made may be anyone of a thousand things which are unknown to us, and about which we can have no opinion; and the changes that we have observed, that is, in the shape, the density, and the motion, which are the most common, can give little or no information, and that little only of a general sort; so that I cannot believe that the philosopher will be blamed who confesses that he does not know, or cannot know what may be the material composing the spots on the sun." But from analogy to substances with which we are familiar, in absolute contradiction to Apelles, no matter what the material of the spots may be, it is not similar to that of stars, but more similar to that of our clouds. This similarity is noticed, because the spots are produced in shorter or longer time, they unite and separate noticeably from day to day, they change their forms, the majority of which are very irregular, their darkness increases and decreases; and as they are in the sun or in close proximity to it it follows that they must be of great size because they are able to obstruct the light of the sun. Sometimes many are produced, and sometimes only a few, and sometimes none at all. In some parts the spots are dense and more opaque and in others less so, in which respect they resemble nothing as much as our clouds. If the earth were less luminous and received no light from the sun, and if it could be observed from a great distance, it would present a similar appearance.

As evidence for these statements Galileo gives drawings of a spot observed early in the month of April and again on its return in May. The drawings* show the changes in the spot during this interval; and it is to be noted, the drawings also show that Galileo had observed the distinction between the umbra and the penumbra of the spots. From these observations and others which he mentions, he again expresses the opinion that the spots are similar in nature to our clouds:

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* Reproduced *Gal. Op.* 5, 107.

> I do not for that affirm that such spots are made of the same substance as are our clouds, which are made of water-vapor exhaled from the earth and attracted by the sun, but I only wish to state that we know of nothing that the spots so much resemble, whether they are vapor, or exhalations, or clouds, or smoke produced by the solar body, or attracted by it from all sides. I am not yet sure, for there are thousands of things that we are not yet acquainted with.

From all the evidence Galileo remarks that the name of stars (stellae) does not suit the spots, for if they were such, either moving or fixed, they would always retain their spherical figure, they would not disappear and reappear, but would always remain the same, they would have a certain movement and period, after which they should reappear the same as before. But they do not reappear the same, and certain ones even disappear when on the face of the sun.

The final conclusion, which Galileo expresses rather as an opinion than as a statement of fact (quoted on page 93), is that the spots are not stars, nor do they move around the sun in separate paths at a distance from it; but that the spots are produced and disappear at the solar surface, that they are attached to it, and that the sun in its revolution carries them around with it.

Regarding the probability of the existence of other planets between Mercury and the sun, Galileo believes that while it is possible, it is however unlikely, for no such planets have been seen. The movements of such planets would be uniform and more rapid than those of the spots, because, being nearer to the sun than Mercury and in agreement with the motions of the other planets, they should move faster and have a shorter period than it. As Mercury requires six hours to transit the sun's disk, another planet nearer to the sun and hence moving more rapidly would require less time than this. Since the spots require a much longer time than this, it is not likely that they are planets.

In concluding this letter, Galileo speaks of the unknown Apelles (whose true identity he apparently first became acquainted with two years later*) with the greatest esteem, as a man characterized by a free and unfettered mind. He voices also the hope that he will be enabled to become personally acquainted with him, as he recognizes him as a man of high genius and a lover of truth. Galileo states also that he will soon forward more detailed observations.

The more detailed observations were included in a second letter,† dated August 14, 1612, but not forwarded until the 23rd of the month. In this letter Galileo states that his recent observations have fully confirmed his earlier conclusions. He affirms that the spots are at the surface of the sun, or, if not, the distance is so small that it is imperceptible. The spots are not stars, or bodies of long duration, for some disappear and new ones come forth. Their duration is from 2 to 5 days up to 30 or 40. Their outlines are irregular and changeable; some spots are seen to separate, and others to unite, even in the middle of the disk. Besides such minor motions they all have a common motion, with which they all cross the disk of the sun in parallel lines. From this it is learned that the sun is spherical, and that it rotates in about a month in a direction from west to east similar to the direction of motion of the planets. The greater number of spots are found in one particular region or zone, which extends about 28° or 29° from each side of the solar equator. The differences in density and darkness, the changes of figure, and the uniting and separating are evident to the senses and need no further discussion; but whether the spots are adherent to the sun, and whether they are carried around by its motion will need to be reasonably discussed, and will be determined from certain phenomena which have been observed.

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* *Gal. Op.* **12**, 29.

† *Gal. Op.* **5**, 116.

The proofs are adduced as follows: First, it is seen that all the spots move with a common and similar movement, although there may be twenty or thirty visible. This is a strong argument for a single cause of motion. This common motion would not be observed if the spots were a number of separate planets revolving around the sun; hence, we must conclude that the spots are in a single sphere which carries them around the sun like the stars (according to Ptolemy), or that they are a part of the sun itself, which carries them with it; of which two conclusions the second appears to be the true one, the other false and impossible. Second, the space over which the spots seem to move from day to day is to be noted. It is observed that the distances traversed in equal times by the same spots are always less when the spots are near to the circumference of the sun, and observing carefully, it is seen that the daily increase or decrease in this motion in equal times corresponds very proportionately to the versedsines and their excesses proportional to equal arcs (molto proporzionamente respondono a i sini versi e loro eccessi congruenti ad archi eguali). This phenomenon could occur in no other motion except circular motion contiguous to the surface of the sun, for should the spots move in circles very far from the sun, the spaces covered in equal times would appear very nearly the same. Third, the changes in the distances between the spots marvelously confirm these conclusions. These distances are small near the edge and increase greatly toward the center of the disk. They are at first very small and almost imperceptible near the circumference, they change with different rates, but always with such changes as could not be met with in any other but the circular motion of divers points variously placed upon the surface of a revolving globe.

Galileo continues discussing these and other proofs, namely, the changes in the appearances of the spots near the edge of the disk resulting from foreshortening, their proximity to the sun, their possible thickness, and the decrease in the darkness of the spots near the edges of the disk; explaining his assertions with the aid of diagrams and geometrical figures, and with a series of drawings of the spots visible between the 2nd of June and the 8th of July. The question is discussed whether the body of the sun rotates and carries the spots with it, or whether the sun is fixed and the spots are carried around it by a sort of fluid envelope. The former conclusion is shown to be the correct one because a medium such as would be required would not be suitable to carry the spots around with it. Further, if the motions of the spots were due to this surrounding medium, it is almost certain that it would communicate the same motion to the solar globe through contact.

Galileo describes at length (to be quoted later) a method of observing the sun and spots without the necessity of looking directly at the sun. This is the method of projection with a telescope, the image being examined on a card or suitable screen. He also states that one can observe without any telescope, the image formed by a small aperture being observed on a far distant screen. He remarks that nature has not limited our facilities for observing, as she has at one time and another produced spots which were large and black enough to be seen with the unaided eye; but a false and venerable belief that the heavens were immutable and incorruptible made men believe that such spots were Mercury interposed between the earth and the sun and that not without shame to the astronomers of that day. Such without doubt was that mentioned in the Annals of the History of France as occurring during the life of Charlemagne, which was described as a spot visible on the sun for eight days. But this was a great error, for Mercury could not remain on the sun longer than eight hours, such is its movement when between the earth and the sun.

Galileo concludes the letter by mentioning that he has received certain observations made at Brussels and at Rome, and that these agree perfectly with his own; proving unquestionably that the spots are far beyond the moon. In a postscript, he states that on the 19, 20, and 21st of the same month a large spot was seen near the center of the sun's disk with the unaided eye, by himself and by many other gentlemen friends. Accompanying the letter are drawings of the sun, showing the spots from June 2 to July 8, and during the three days in August when the large spot was visible.

As Scheiner was unable to read Italian—this he learned during his stay in Rome some years later—he did not become acquainted with the contents of Galileo's letters until Welser had had them translated for him. But even before Galileo's letters had been written, Apelles sent two additional letters to Welser, dated January 16, and April 14, 1612.

In the first[*] of these letters, Apelles commences with remarks concerning the supposed transit of Venus and conjectures regarding the failure of its appearance; that the ephemeris of Magini may be in error, etc. The results of his later observations of the spots are; that the spots seldom retain their figure from the time that they first enter the disk until they exit, the spots always appear larger in the middle of the disk and smaller near the circumference, the border of the spots is always rough, and the majority are not as dark at the edge. Round spots are extremely rare, while those with irregular shapes are more numerous. The spots appear like dark snowflakes, pieces of cloth, masses of hair in front of a torch, etc. They all seem to move more quickly in the middle part of the sun than near the edge. All move parallel to the ecliptic. Those that cross near the center of the disk move more slowly than those more distant from it. Two spots are noted, one of which required 16 days to cross near the center of the disk, while another farther from the center required only 14 days, which fact convinces Apelles that the spots cannot be adherent to the sun. The motions and appearances of these two spots are discussed in some detail. The first one was contracted when entering the disk, but expanded in the middle and contracted again at exit. The second is compared to the appearance of Mercury during a supposed transit as observed by Kepler, with the conclusion that the spot is much larger.[†]

Up to this time there is no evidence that Scheiner had made specific claims for himself as the first discoverer of the solar spots. This, however, he does later in the *Rosa Ursina.* But at the end of the letter of January 16th, he makes something very like a claim, when he remarks to Welser concerning his fears, that if any one should hesitate over the announcement of a discovery, it is possible that others may anticipate him. He writes:[‡]

> Hence I fear that unless you hasten to be first, these [the spots] will be snatched from my hands, for when the great import of the matter is perceived, the mathematicians will not be able to restrain themselves, but they will hesitate when they consider by how great an interval they follow us, and hence they will either produce their own and proper things, or certainly will not claim that which belongs to others. You alone can prevent this, may Providence bring it about, that, as we have begun this so may we happily carry it forward and finish it.

If this quotation is considered as showing the condition of Scheiner's mind at this time, it would seem to indicate that he was aware that someone else had also observed the spots but had neglected to make the proper announcement, and that if the letters were speedily published by Welser he would still be put on record as the first observer. Hence the appeal; but this will be discussed in detail later on.

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[*] *Gal. Op.* 5, 39.

[†] In this instance Apelles was probably correct in his conclusion.

[‡] *Gal. Op.* 5, 54.

The second letter* (April 14, 1612) is almost wholly concerned with the account of the discovery and observation of a supposed fifth satellite of Jupiter on March 30, 1612, and which Scheiner subsequently dedicated to his patron Welser. It is of interest to note that Winnecke† has shown that there was no error in the observations of Scheiner, but he had unknowingly observed a variable star.

(To be continued.)

NICOLAUS COPERNICUS.

CHARLES NEVERS HOLMES.

Ptolemy's idea of a stationary earth and a moving Universe had survived for centuries longer than it should have, and in Nicolaus Copernicus we find the man who completely shattered Ptolemy's idea. More than 2000 years before, the famous Pythagoras had believed in a moving earth and a central sun, but the naturalness and simplicity of this belief had been overwhelmed by the arguments of Ptolemy. The Ptolemaic System had a firm and traditional hold on the minds of men, and at first the doctrine of Copernicus was rejected or coldly received. But although it may take generations and generations of time for a great error to be corrected, nevertheless truth in science as well as in other important matters will ultimately be triumphant.

Nicolaus Copernicus was born at Thorn in Poland, on February 19, 1473. His father was a Pole, his mother a German. His family did not belong to the nobility, in fact his father was a tradesman. Very little is known respecting the youth of this future great astronomer. He was educated at home, then sent to the University of Cracow, where despite the incompleteness of his educational equipment, Copernicus studied diligently, particularly medicine, theology, mathematics and astronomy. In 1496, in his 23rd year, he went to Italy, residing two years at Bologna where he studied canon law and astronomy. At Cracow it had been his intention to be a doctor; but by the advice of his uncle, Bishop of Ermland, he gave up this profession and prepared himself to take holy orders, being appointed in 1497, while yet in Italy, a canon of the Cathedral of Frauenburg.

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* *Gal. Op.* **5**, 54.

† *Vierteljahrsschrift der Astronomischen Gesellschaft*, **13**, 283.

In 1500 Copernicus visited Rome where he lectured on astronomy, for his mathematical mind had induced him to choose that science for a profession. In 1501 his uncle, Bishop of Ermland, died, and about that time he settled permanently in Frauenburg, although he lived afterwards for some years at Heilsberg. At Frauenburg he combined a number of offices and duties, such as military governor, bailiff, judge, tax-collector, vicar-general and physician. Copernicus was appointed administrator-general of the diocese of Ermland in 1517. He seems to have led a very laborious and industrious life at Frauenburg, with his theological duties, attending the poor medically, and his researches in astronomy and mathematics. But his chief interest must have been in his great work, "De Revolutionibus Orbium Coelestium," a book in six volumes, whose arguments shattered finally the Ptolemaic System. Although his astronomical labors occurred centuries after the time of Ptolemy, astronomy was yet in its infancy, and all the work of Copernicus was accomplished before the invention of the telescope (1610).

The belief of Pythagoras appealed to Copernicus, as it seemed more natural and more reasonable that our earth should revolve around the sun than that the opposite should be true. He began to look into the matter carefully and became more and more convinced that the theory of Ptolemy was utterly erroneous. The daily rotation of our earth on its axis, explained by Ptolemy as due to the movement of a vast crystalline sphere in which the distant suns were fixed, seemed to Copernicus far more simple and sensible. Copernicus admitted that this apparent motion of the sun and suns was caused either by the sun and distant suns revolving around our earth or by motions of the earth itself. Ptolemy had denied utterly any motion of our earth; but Copernicus came to the conclusion that this apparent motion was the result of a movement of our world.

Copernicus argued that people on board ship moving through quiet water, would think the vessel at rest while houses and trees on shore seemed to be in motion. This was the same illusion that had deceived those who believed in the theory of Ptolemy. Not being able to perceive our own terrestrial motion, we might imagine that the sun and distant stars were revolving around us whereas their apparent movement was wholly caused by the rotation of our earth. Ptolemy had declared that were the earth to rotate, the air would not rotate with it, and the world would not be habitable, owing to the terrific wind rising from the velocity of the earth as it revolved rushing through the air. To this Copernicus replied that the atmosphere would accompany the rotation of the earth, exactly as one's coat accompanies him, whether he is standing or walking.

Ptolemy had asserted that all the distant stars were attached to the surface of the celestial sphere, each star being at exactly the same distance from the world. Copernicus declared that this so-called celestial sphere could not really have a material existence, for such a conception was not natural and it was not necessary that every star should be placed at exactly the same distance from our earth. There was no good reason why these stars should be so fixed and the whole theory of such a crystalline sphere seemed very unnatural, Also, there was a question of what sort of substance composed this sphere as well as the problem of its thickness and whether or not something did not lie back of it, on the other side. In fact, such a sphere was too complicated and wholly unnecessary. How much more simple and how perfectly natural to believe that our earth revolved around the sun just like Mars and the other planets.

Thus Nicolaus Copernicus carefully thought out his celebrated Copernican Theory; and, studied from the standpoint of past centuries and modern science, it is evident that this theory is true. In fact it has hardly any need of argument, particularly in the light of 20th century astronomical research. But although Copernicus gave us this immortal Theory, although he explained certain other things about Mars and the planets, he could not exactly understand regarding their orbits around the sun, and this astronomical work was left for the great Kepler.

Copernicus was well known at the time not only as an astronomer but also as a mathematician. He wrote a treatise on trigonometry in 1542; and he also made a translation in 1509 of the epistle of the Byzantine writer Simocatta.

But although Copernicus completed his "De Revolutionibus Orbium Coelestium" in 1530, it was not given to the press until some 13 years afterwards. He hesitated for a long while about giving his work to the world, because of the opposition and controversy that it would arouse. At last his friends became so insistent that he decided to publish it, but before it appeared Copernicus was taken mortally ill. On May 23, 1543 a copy of the book was brought to him, but he died a short time afterwards. "De Revolutionibus" was, therefore, first published in 1543, at Nuremberg; but there were later editions at Basel (1566), Amsterdam (1617), Warsaw (1851), and at Berlin (1873).

Thus, lived and died Nicolaus Copernicus, who rescued our world rom the error of the Ptolemaic System. A good, learned, industrious man; a remarkable and valuable career. Astronomy saw its first real dawn in him, with all honor to those who groped in the darkness of science before him. The error or the truth about a great fact does not change the reality of that fact; but man wants to know the truth rather than the error about astronomical science, and therefore our world owes a deep debt to Nicolaus Copernicus of Frauenburg.

Hotel Nottingham,
Boston, Mass.

THE DISTRIBUTION OF GASEOUS MATTER THROUGHOUT INTERSTELLAR OR COSMIC SPACE.

THEODORE WILLIAM SCHAEFER, M. D.

It has been supposed for a long time that the space that separates us from the sun is a desolate void not containing any air or other known substances of a gaseous like nature, except the mythical something or hypothetical medium called the ether, by means of which energy is transmitted in form of undulations through space. In a similar manner it has been supposed for a long time that this same immensity of space is at absolute zero temperature, having so been affirmed with an evident assurance of certainty and supported by a plausible display of mathematical calculations. The first supposition has just been successfully assailed by a few eminent scientists and there appears to be a gradual natural philosophical regression with respect to this conception which was firmly believed until recently. The second supposition, however, that of the assumed absolute zero temperature of space, has not been courageously attacked by men of science. It still flourishes in scientific works as a pet, traditional, scientific fiction.

Ancient and Modern Views of Our Atmosphere and Heavenly Space.

In antiquity, when it was assumed that the earth stood still in the center of the world, the ancients concerned themselves but little about the limits of the terrestrial atmosphere. The region of the clouds, lightning and meteors was considered the upper boundary of the atmosphere.

Anaximenes of Milet and Diogenes of Apollonia, who lived in the fifth century before Christ, placed the primordial matter of all things in the air. A distinction was made even in antiquity between the air and the ether (Aristoteles). During those times it was not perfectly clear whether the ether possessed the all-penetrating importance that is given to it to-day in our physical theories or whether the ether, unlike the air, was to be considered the essential material medium filling the heavenly space beyond the highest strata of the air. This uncertainty, however, of the limitations of the atmosphere vanished as soon as a rotary movement of the earth and subsequently a revolution around the sun became known.

According to the nebular hypothesis of Kant and Laplace the whole interstellar or cosmic space was originally filled with gaseous matter, including air.

THE HITHERTO PREVAILING IDEAS OF THE HEIGHT OF THE ATMOSPHERE OF THE EARTH AND THE MATERIAL CONDITIONS OF THE COSMIC SPACE.

The atmospheric envelope surrounds the solid body of the earth in the form of a hollow spheroid. Its height has been calculated from the instant that meteors flash and after the disappearance of the blue color of the sky when twilight is approaching and after other signs, to be approximately from 200 to 250 kilometers. Of course, these figures are only of relative value and for the time being. But beyond and further into space rarefied gases fill the space between the planets and the sun: Gases which we have designated in antithesis to the atmosphere of the earth as the atmosphere of the heavens and which are clearly to be differentiated from the ether, that assumed medium, which is supposed to fill all intermolecular space of ponderable matter and which transmits the electrical, heat and light phenomena. While the atmosphere of the earth still participates in the movements of the earth, there are other and more distant strata of the air that no longer or not so completely take part in the rotation of the earth, *i. e.*, remaining relatively quiescent, but are, nevertheless, carried along in the moments of the earth around the sun and then further on as the earth, including the whole planetary system, wanders through the world of space.

A numerical limit between the heavenly atmosphere and the atmosphere of the earth has not been estimated, says Supan,* but from the observations of the "silvery clouds" (Jesse's night clouds) we know that already at a height of 82 kilometers the strata of air are no longer in full dependence on the rotation of the earth.

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* Grundzüge der Physischen Erdkunde von Prof. Dr. Alexander Supan, 1908, p. 50.

From certain perturbations or so-called movements of resistance observed in cometary formations in the inner space which is in proximity to the sun, we infer the presence of ponderous cosmic matter, gaseous and ultra gaseous elements, besides the universal ether. If our cosmic space were filled exclusively with the universal ether we should not anticipate any perceptible resistance offered to the movements of the earth. Inhibitory effects, however, have been noticed in the movements of swarms of fine particles of cosmic matter out of which certain cometary forms are composed. This resistance has been clearly proven to be the case in a striking resistance with Encke's comet. There is a constant presence of material elements of a coarser kind existing in the space surrounding the sun between the planetary paths. In short, it can now be maintained with great certainty that the space of our planetary system is not only filled with the ideal medium called the ether, but also with small and very minute elementary masses of a solid or gaseous nature, and, furthermore, probably a part of these material elements describe a planetary movement around the sun, whereby the resisting action of this part that fills the space against the movements of the planets is naturally diminished. On the other hand, another part of the material elements, essentially under the influence of the power of the attraction of the sun, attracted by the latter from their cometary paths of the outer planetary space, wander through our system and at the same time cross the paths of different planets, and finally penetrate very often their very atmospheres as well as the atmosphere of our earth.

It is evident that in such a manner cosmic matter, of a solid nature, containing occluded gaseous matter, enters our atmosphere with great velocity and often in a state of incandescence. The whole problem of the conditions of the highest strata of the atmosphere becomes indeed important if we conceive of a space filled with cosmic dust, gaseous and ultra gaseous matter. It is indeed conceivable that traces of counter actions occur in the highest strata of the air, where very complicated and peculiar movements must obtain. We refer to the illuminated trail of meteors or shooting stars, luminous clouds, etc., that leave a lighted path along their passage. To all these phenomena we have first of all no other choice than the assumption of counter actions of a cosmically filled space through which the earth, in its path around the sun, is moving with the enormous velocity of 30,000 meters per second.*

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* Von der Erdatmosphäre zum Himmelsraum. Von Professor Dr. Wilhelm Foerster, 1906, pp. 9-24.

Arrhenius[*] has calculated the amount of matter that falls upon the earth from cosmic space to be about 200 tons a year. The action of this dust is, nevertheless, considerable on account of its fine attenuation and it should constitute a far larger amount in the higher strata of the air than is furnished by the downfall of meteors or falling stars. These particles of matter carry off gases from the sun which are capable of condensing on their surface, which existed originally in the chromosphere and corona of the sun. Particles of dust take up the rays of the sun and give their heat to the individual molecules with which they collide. Ionized gases possess the remarkable property of condensing vapors. Wilson has shown that the negative ions possess this property to a higher degree than the positive ions (by condensation of watery vapor). If, therefore, vapors in the vicinity of the sun, which become cooled, and condensed, the formed drops of water will be precipitated at first upon the negative ions. When the vapors are driven away by "radiation pressure" (Arrhenius) or fall down in consequence of gravity, like the rain drops in the atmosphere of the earth, they therefore carry the charge of negative electricity, while the corresponding positive electricity remains in the gas (respectively the air). In this way the negative and positive charges are separated from one another and electrical charges may be the result if sufficiently large quantities of electricity are separated from one another. In consequence of these discharges which pass through the gases the latter become luminous, although their temperature may be apparently very low. It is probably worth mentioning that the strongest spectral line of the Northern Light (Aurora Borealis) has been found to belong to the noble gas krypton. As this gas occurs but in minute traces in the atmosphere, it is not improbable that it is carried with the solar dust (occluded) and that its spectrum, therefore, appears on its electrical discharge. Recent investigations make it probable that the noble gases discovered by Ramsay, which are similar to argon, neon and xenon, and which have not yet been separated from the nitrogen spectrum, likewise take part in the formation of the spectrum of the Northern Light. Krypton,[†] found in the infinitesimal proportion of one to twenty millions, glimmers in the Northern Light. Of special importance is neon's transmission for electrical light. Air requires 1,000 volts, neon requires but thirteen volts. The blue color is absent in the spectrum of neon, its coloring being somewhat *red*. Indeed, some very interesting experimental researches of Birkeland, published in the *Scientific American* Supplement, July 5 and 12, 1913, on the Aurora Borealis, render it probable that the phenomena is due to corpuscular radiation proceeding from the sun to earth. Among other things, gases can be ionized by being charged with Röntgen rays, cathode rays or ultra violet light as well as being strongly heated. As the rays of the sun contain much ultra violet light, it is undoubted that the masses of gas in the vicinity of the sun (perchance in the case of comets that come near the sun) are partially ionized and contain positive as well as negative electricity.

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[*] Das Werden der Welten. Von Svante Arrhenius, 1907, pp. 4-189.

[†] Erdmagnetismus, Erdstrom und Polarlicht. Von Dr. A. Nippoldt, Jr. 1903, p. 120.

GASES ARE CONTINUALLY LEAVING THE ATMOSPHERE OF THE EARTH AS WELL AS OTHER CELESTIAL BODIES AND ESCAPE INTO THE GREAT COSMIC SPACE.

The kinetic theory of gases gives a simple explanation for a number of highly interesting observations which concern the gaseous atmosphere of the heavenly bodies. The hypothesis evolved by the eminent Dublin scientist Dr. Johnstone Stoney,* contains a considerable element of truth. It is simply this: Gases are continually leaving our atmosphere, owing to the intrinsic rate of motion of their molecules. For example, when a molecule of hydrogen arrives at the confines of our atmosphere it may escape, provided its rate of motion is sufficiently rapid. And it may be proven that some molecules of hydrogen possess sufficient velocity to carry them beyond the sphere of the earth's attraction. If given ample time, all molecules of hydrogen would ultimately fly off and would find a home when they reached a body of sufficient mass, and, therefore, of adequate attractive force to retain them permanently. The sun is such a body; and it has been abundantly proven that free hydrogen exists in quantity in the solar atmosphere.† The chief objections to Stoney's deductions have been logically removed. Among the gases hydrogen and after this helium and other noble gases, including those of an ultra gaseous nature, play the chief role. Some of these gases occur, though in small quantities, in the atmosphere of the earth, others occur in nebulous masses and larger celestial bodies. As far as hydrogen is concerned, Sieveking and Mitchell maintain that it is not generated in the atmosphere of the earth. From the kinetic theory of gases the inference is drawn that isolated molecules of gas must constantly leave the atmospheres of planets, as soon as their velocity should accidentally become so great that they overcome their attraction. Stoney has drawn attention to the fact that a body that is moving upward from the earth with a velocity of 11.2 kilometers per second would no longer be held back by the gravitational force of the earth, but would fly off into infinity, apart from the consideration of the attraction of the sun. According to the laws of probability there must be some also among the molecules of a gas that have attained the necessary velocity, and, conversely, there are some which are not sufficiently swift, to abandon even the smallest heavenly body. No planet can (in empty space) possess theoretically an absolutely permanent atmosphere, and none can have lost it completely. When the number of molecules with sufficient momentum has become very small, then the atmosphere can be actually considered as nearly permanent. For those gases that have a low specific gravity and therefore a greater average velocity (the density of oxygen O is 16 to hydrogen H, the average distance of the path of the molecule H is therefore four times greater) the probability is greater, that single molecules attain accidentally the extraordinary speed that is essential for abandoning the atmosphere. Of this kind of gases more escape than from the denser ones. This process will remove in the course of time all gases from the atmosphere of planets of definite mass and force of attraction, whose density is below a certain limit. The velocity that is essential to leave the earth must be five times greater than the one necessary to leave the moon, as the potential of the earth is 25 times greater than that of the moon. For this reason the moon can possess but a barely perceptible atmosphere, as even the lightest gases, like hydrogen and helium, have wholly or nearly wholly escaped from the atmosphere of the earth.* The often repeated contention, so ably advanced by Friedel, Foerster, Birkeland and others, that the interstellar space is supposed to be filled with fine cosmic dust, representing many elements, seems, therefore, to be of far reaching importance. Birkeland, however, believes that the interstellar space is airless. That originally corpuscular matter in the form of supposed electrons, possessing great penetrative and accumulative powers, should have for ages filled cosmic space, is, indeed, not a new idea. Theoretically, Foerster, Stoney, Friedel † and others have for a number of years advanced this supposition. Birkeland, starting with experimental analogues, has studied practically the action of electrical discharges in "vacuum chambers," which he compares with cosmic phenomena like the zodiacal light, etc., which seems to be of great importance in understanding solar phenomena and the evolution of all celestial bodies of the universe.

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* Johnstone Stoney, *Astrophysical Journal* **7**, 25 (1898); **9**, 1 (1899) **11**, 251-357 (1900); *Nature* **61**, 515, (1899).

† The Gases of the Atmosphere, The History of their Discovery, By Sir William Ramsay, K. C. B., F. R. S., 1905, pp. 265,266.

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* Lehrbuch der Meteorologie von Dr. Julius Hann, 1906, p. 2-3.

† Johann Friedel, Petermann's Mittheilungen, 1905, p. 43.

From these different points of departure of the reflection of the limitation of the atmosphere of the earth we logically come to the conclusion that there is actually no real limit of our atmosphere and that beyond the atmosphere cosmic space must be filled with gases which are exceedingly rarified.

MARS AND ITS MARKINGS.

HARRY HUSSEY.

Having followed the sea as a profession for many years and for as many years having worked in astronomical observatories I have been much struck by the similarity of the conditions governing the seeing or observing, both in an observatory and on board ship. When I left the sea I had attained the rank of second officer of a tea clipper, and though working in a subordinate capacity in observatories, yet I have had innumerable opportunities for observing and can speak as one having some knowledge of the subject.

Sailors are merely ordinary men specially trained, and other things being equal, their eyes are in no way superior to those of landsmen, that is, as eyes; but owing to long practice they can with ease pick up an object at sea that is invisible to a passenger. This I have noticed more times than I can remember, not only on board ship but also in an observatory, for the same rule holds good in both places. One observer can see easily planetary detail that is invisible to another who has had less experience, just as the sailor can see that which is invisible to the passenger.

What would be thought of a passenger who when a distant vessel had been pointed out to him by a sailor, he had replied, "There is no ship there, how can there be when I can't see it, and I have good eyesight." What could one say of such an one?

Yet, when I went to work in an observatory I found, to my great astonishment, that there were men of little or no experience in observing planetary detail (passengers) who denied the existence of markings that were easily visible to observers of long experience (sailors).

I am not a skilful observer, yet I have seen with ease and distinctness the more prominent of the "canals" of Mars, not only with the 24″ of the Lowell Observatory but also with the 60″ mirror of the Mount Wilson Solar Observatory, and I have drawings made from observations with both instruments.

The conditions for observing at Mount Wilson were not good, we had to hold the eye-piece in our hand and rest the arm on the telescope, nevertheless I could see "canals" which are shown on the drawings I made there.

During the three years I was at Mount Wilson, the 60″ mirror was turned on Mars twice for visual observations, one of the times the seeing was 8 on a scale 10 (10 being the best) for steadiness, but with a fine blurring over the surface of the planet, the other time the seeing was not so good, and to me the definition of the big mirror did not seem nearly as good as the Lowell 24″, but, of course, one could not say that with certainty after only two short tests, also taking into consideration the mechanical difficulties one had to contend with at the eye-piece.

There is one thing I have run across in my observatory experience, which I have never met at sea, and it seems hard to believe, but I have seen it shown so plainly and often that I *must* believe it; it is this, there are not only those who from lack of experience are unable to see "canals" or even well-known markings, but there are others who do not want to see them and won't see them, and, of course, "There are none so blind as those who won't see'"

What their motives are I cannot conceive, but that there are such men is a fact for I have both seen and heard them.

One such man I remember distinctly whose point of view was this, "Oh, what's the use of looking, there are no canals, its all foolishness, anyhow." Now this, I would hardly call an unbiased or unprejudiced state of mind in which to approach the subject, yet he is not alone in his way of looking at it, I have met others: but it is a two-edged weapon, for I have known people who could not see the Fastigium Aryn, a well-known marking which the above mentioned man *could* see, yet by following his own method of reasoning (if one may call it reasoning) these people could say he was mistaken, how could there be such a marking when they were unable to see it?

I can recall the sorrow and astonishment I felt when I ran across this kind of thing first. Astronomy I had always known to be the noblest of all sciences, and by inference I had thought astronomers to be the noblest of men, far removed from all the petty meanness of common humanity.

Of course, no one can expect to see fine (I was going to say faint, but it is by no means faint with good seeing) planetary detail if he only looks occasionally and casually at the planet, any more than a young seaman can become a trustworthy lookout man if he keeps his eyes on the deck all the time.

Yet I have found very clever men, after only three or four casual observations of Mars, under very indifferent conditions both mechanical and atmospheric, who would make positive statements as to the existence or non-existence of planetary markings.

I have just experienced a good illustration, both of the value of good seeing and of practice.

Last week I looked at Mars for the first time since I left Mount Wilson six years ago. Mr. Slipher was observing and had just seen the Propontis, he asked me to look and see if I could see it: he told me where to look for it, but I could not see it, in fact I could see only a confused and blurred mass of faint markings; which to Mr. Slipher's practiced eye, were by no means confused or blurred. There being no one ready to observe, I stayed at the eye-piece idly watching the planet, and the seeing became better and better until there gradually came one of those periods of superlative seeing for which this Observatory is famous (I believe it was located here for that reason) and not only the Propontis but every marking on the planet as plain to be seen as if it was a photograph or a printed map. It was mighty interesting and I don't care how blasé or uninterested a man is, such an experience will cause him to exclaim with joyful amazement.

When I speak of the image being confused or blurred I do not mean the planet as a whole; that is, the planet may be perfectly still with a sharp cut rim, and yet there will be a fine blurring all over the surface: an inexperienced observer would call that kind of seeing very good and for most kinds of astronomical work it would be good, but for seeing or photographing fine detail it would not be good.

What a revelation these periods of perfect seeing would be to some of the doubting Thomases I have met! I am very certain even they would be unable to repress the exclamation of amazement which every man utters when the perfect image first comes into view before him, though I have met one man, who I am very sure would shut his eyes when the perfect seeing came, and I suppose there are others.

Whether it is owing to the configuration of the surrounding country (which is unique) or the altitude or the geographical position or a combination of all three, I do not know, but here at the Lowell Observatory there are certainly periods, during a night of good seeing, when the seeing is perfection, and adding to this a flawless objective one should not be surprised at the results obtained by the observers here.

But I have wandered away from my subject, which was to point out the similarity of the conditions both on board ship and in an observatory in regard to seeing faint objects. To my mind, the analogy is complete, even to the cry of joy which I have heard many times both from passengers on ship-board and observers at a telescope when they first see an object which up to then had been invisible to them (though visible to experienced men) and which they almost or quite doubted was there.

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SOME INTERESTING ASPECTS OF THE SIDEREAL UNIVERSE.

HENRY HANDY McHENRY.

There is nothing that impresses one so completely with his own insignificance as the contemplation of the wonders of the sidereal universe. The egotism of even the most famous of mankind must surely vanish when he views those vast worlds hurtling their way thru the limitless voids of space. It is noteworthy that all men who come closely in touch with nature are modest and unpretentious, so long as their researches are conducted in the simple spirit of learning the truth for its own sake. It is only when actuated by worldly motives of greed and desire for fame that they lose that splendid humility which characterizes the sincere scientist when in the presence of the sublime wonders of the infinite cosmos.

Viewed from the physical standpoint of our earthly experience even the grand total of human achievement since the advent of Man is as nothing compared to the mighty forces at play, creating, remolding and destroying worlds millions of times the size of our sun, with never a moment's rest. John Burroughs has written at length on the marvels of the infinitesimal world of atoms and electrons whose ceaseless eruptions are ever with us though too minute to be perceived by the most powerful microscopes. This is, indeed, a wonderful world to contemplate, but it seems to me that the conceptions of the infinitely big, encountered in Astronomy, are even more magnificent.

I will name some of the facts disclosed to us in the great field of Astronomical Science of which we can only form a dim idea. To attempt to truly picture them is beyond the scope of the human imagination. Even the great minds who discovered the laws of planetary motion and sidereal velocities have confessed themselves incapable of appreciating the full magnitude of their works.

The marvels of our own solar system are not to be overlooked. But sublime as the phenomena of the planets are, they pale to the commonplace when compared with the infinitely staggering facts of the sidereal universe as a whole.

Although light travels at the rate of 186,000 miles a second it takes nearly four years for the light to reach us from the nearest star, Alpha Centauri in the Southern Cross. In fact the parallax or vertical angle, from which the distance is computed, of only about one hundred and twenty five stars has been even approximately determined. Using the greatest diameter of the earth's orbit as the base of the triangle, and the star as the apex, the greatest parallax known is only three-fourths of a second of arc! It is probable that the stars in the Milky Way are from seven hundred to a thousand "light years" away, and as the power of stellar photography has increased, more remote stars are continually revealed. Just think of it! Many of these stars we see not as they existed in our own time or even in that of our forefathers, but as they were before man lived on earth! Perhaps there are some that the people of this world will never see.

Undoubtedly many of the stars we see today have burned up hundreds of years ago and are merely cold, dark bodies tossing helplessly about in space. When a star first begins to condense from a gaseous nebula, it is blue in color. As contraction continues it becomes yellow, which at old age merges into red. Following that the star soon loses its light and heat. I say 'soon.' The life of a star is only a matter of a few hundreds of millions of years. Green stars such as Castor, or orange like Albireo, at the foot of the Northern cross, obtain their color from chemical elements which they contain, existing in a highly incandescent state.

The sun is now in the yellow or middle aged state. When it burns out, the earth will have become too cold to support life, at least as we know it. Science has calculated that the sun grows about a degree cooler each day.

The heat of these stupendous bodies is inconceivable as well as their size. The star Altair radiates ninety times as much heat as the sun. Rigel in Orion, is so far away that its distance has never been even approximately calculated, but its brightness indicates it to be a tremendous reservoir of heat. Arcturus is more than two hundred times as large as the sun.

We are accustomed to refer to the stars as 'fixed', but as a matter of fact nothing is less immovable. Every star is travelling thru space at a tremendous velocity. The greatest stellar velocity known is that of a star in the constellation of Cygnus which loiters along at the rate of five hundred miles per second. Our own sun with its attendent planets is rushing toward a point in Hercules at eighteen miles a second. When we get there the stars in that vicinity now will be hurrying thru some other part of the universe. Inside of a few million years the Big Dipper, Orion and other celestial landmarks will have ceased to exist. We shall have to find a new Polaris to guide our ships by. Arcturus, which has a greater velocity than any other first magnitude star, is said to have moved a little more than a degree since the evening it attracted Job's attention.

Undoubtedly collisions have occurred between these cosmic cannon balls. The sudden appearance for a brief period of a bright star hitherto unknown, and the equally sudden disappearance of an old celestial friend leads astronomers to believe that stars occasionally collide with each other, especially the myriads of invisible, burnt out bodies that glide thru space like mysterious gigantic monsters. What an inconceivable cataclysm must take place! A terrible rending of worlds, a breaking up of vast continents into a conglomerate mass of molten matter, and fire, far surpassing the most terrible earthquakes and conflagrations we have recorded in history!

The impossibility of life existing as we know it on the planets, has been generally established—even for Mars. But one must not forget that in all probability millions of the stars are, like the sun, the centers of an invisible retinue of planets and satellites, perhaps even more vast and complex than our own solar system. Surely it is not likely that our planet is the only one in the whole cosmic universe capable of supporting human life. There may be planets where races of human beings live whose civilization surpasses ours by an even greater margin than we have advanced beyond the ignorance of primitive man, to say nothing of the possibility of life existing of a totally different nature. Bergson has declared that the chemical affinity of the carbon, oxygen and hydrogen atoms is the genesis of all biological species. May there not be worlds where other elements unite to create species of an entirely different type?

We well know the utter futility of attempting to form an accurate mental conception of the minute atoms and electrons of which matter is composed. But, seeing the futility of grasping that which science has proven, may there not, by analogy, be an infinitely greater *universe* than we have as yet suspected? The people in such a universe would regard the stars and their attendant planets as we regard the positive atomic nucleus and its attendant negative electrons. They would be infinitesimal—invisible save in the minds of these Brobdingnagian scientists. The possibility of such a super-cosmos seems to me to be the most appalling conception the human mind can venture to create.

The achievements of the masters of astronomy whose lifelong labors have given us the key to the secrets of the universe cannot be praised too highly. They have contributed not a little thru the enlightenment shed broadcast to the advance of civilization. The miracles attained in perfecting the telescope, the development of stellar photography, and the valuable discoveries made possible thru the spectroscope—to say nothing of the infinitely abstruse mathematics required to compute even the simplest planetary and lunar tables, are immortal monuments to the ingenuity of mankind. We are far too inclined to pass over these purely mechanical aspects of astronomy, yet they are the tools without which we would have been as ignorant of the laws governing the universe as our ancestors were in the Dark Ages. The names of Galileo, Brahe, Kepler, and the Herschels will live forever among the great servants of humanity. Nor must we forget the modern astronomers such as Adams, Le Verrier, Pickering, Hale, Campbell, Frost, Moulton, Barnard, Larkin, and Chase, whose work has been of noteworthy value.

But let us turn from the sublime to dwell awhile on the aesthetic nature of the celestial vault. We feel a certain intrinsic loneliness while beholding these peerless jewels, of a distinctly individual character. I doubt if the sentiments of the lover of lake, mountain, or floral beauty are equal to those of the ardent star gazer. To one acquainted with the geography of the heavens, the first magnitude stars and the more impressive constellations assume the rôle of old friends. What a sense of security and comradeship it must give the sturdy arctic explorer when his way across the frozen wastes is brightened by the familiar rays of Vega or Capella! It is akin to the light that guided Leander when he swam the Hellespont.

What pleasant memories are recalled by Orion's splendid array gleaming far above the restless metropolis on a wintry night of that wonderful sail we had last summer when we glided lazily thru the quiet phosphorescent waves until when dazzled by the advent of Sirius above the eastern horizon we were reminded that it was well nigh unto daylight. Truly to him who has sensed the infinite charm of the celestial host belongs untold riches—treasures not to be envied because others fail to appreciate the subtle significance which lends them a rare tone.

The stars have always possessed a certain sense of mystery—their effect on some people is almost hypnotic. One sometimes feels as if his deeds are diurnally weighed by those strange nocturnal eyes, seeming to pierce the shadows of the soul itself. The imaginations of the Ancient Greeks were lured into building up impossible resemblance to bird, beast, and fish from the configurations of the stars. Most of the constellations still retain these ancient names, though there are some new ones such as The Sextant and The Clock. While the outline of The Hunter, The Sickle, and The Northern Crown are apparent to all, it takes a stretch of the imagination to discover The Lizard, The Swan, or The Horse. Likewise we find that superstition has attached itself to the stars with greater tenacity than to almost anything else. Astrology once held the place of the most dignified of sciences, and its teachers were revered as the greatest intellects of their time. Even now there are people whose superstitious natures cause them to still cling to this obsolete necromancy. Today there exists a College of Astrology in Portland, Oregon!

The mystery of the Pleiades is still as impalpable as it ever was. There they lie, seven sapphire gems embedded in a nebulous veil. Countless legends have been wrought around them. At one time it was declared that the Pleiades were the fixed center of the entire universe which revolved around it in cycles of seven hundred years. The mystic number 'seven' is significant here. Neither can we forget the fabled "music of the spheres." Each heavenly body was said to give forth an individual vibration, and all in motion simultaneously produced a harmonious music which magicians and seers declared they sometimes heard.

Symbolism abounds in the heavens for one who is prone to indulge in such fancies. Fomalhaut, the Lonely One, that prominent first magnitude beacon in a comparatively starless void in the south, gives the impression of a great mind far in advance of his contemporaries, such as Buddha, Christ, or Newton. The fiery Antares and his brilliant retinue constantly remind one of the Lord of The Mailed Fist, while the Great Nebula of Andromeda seems to represent the genesis of the work of future generations, as yet uncrystallized from the realms of abstract thought.

For the happy star gazer who can afford even an inexpensive telescope a whole world of new wonders is revealed. The sky appears to be suddenly populated by millions of newcomers. We can examine at leisure many magnificent multiple systems—two or three stars constantly revolving about each other. Sometimes one of these is a dark body causing variability of brightness, like Algol which changes from second to fourth magnitude every four days. The splendors of many exquisite nebula are laid before us such as the Ring Nebula in Lyra, and the beauty of those in Andromeda and Orion are increased a hundred fold.

In urging a popular education in astronomy one might remark that our children would never be homesick if they learned to recognize the heavenly host that still watches over the familiar home scenes. But seriously speaking, I think that astronomy should be included in every high school curriculm. Not the mathematical side, of course, as that is too technical and uninteresting for most people, but a thorough knowledge of the fundamental facts of physical astronomy. In these practical days education has been largely transformed from mere book learning into a means of preparation for our careers. Nevertheless a very proper reaction has set in, and it is becoming more and more apparent that it is desirable for every student to carry several purely cultural studies.

Certainly astronomy should be included among this group. It is only reasonable to require that every well-informed person should possess an elementary knowledge of our solar system besides at least a bowing acquaintance with the geography of the heavens. As I have hinted above, even an imperfect conception of the great cosmic forces at work in the universe helps one not to over-emphasize the importance of his own Ego, and instilled in the minds of the young would constitute a potent influence against the exaggerated materialism of the present time.

VENUS IN THE WEST.

The gloaming lingers and yon western sky
  Is darkly blue—another night draws nigh;
A wintry shroud lies white o'er vale and hill,
  The frosty air grows colder—all is still,
A crescent moon sets wanly, then afar,
  Serene, resplendent, shines an ev'ning star!
Amid the dark, supernal dome of night
  It hangs like mirror of celestial light,
And pearly white above a knoll's black crest
  Once more is Venus regnant in the west.

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REPORT ON MARS, No. 15.

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In has occurred to the writer that there may be some persons interested in Mars who would like to make useful observations of the planet, but who do not know precisely how to begin. It is proposed therefore to devote a few pages of this report to a description of the proper use of the Ephemeris, as published in the Nautical Almanac. It is possible also that even some regular observers may find a suggestion here and there that may be of use to them. A very elementary knowledge of trigonometry is necessary in laying out the proper angles, and will be assumed. What is stated here applies directly to the *American Nautical Almanac*, but it applies nearly as well to the *British*, the main difference between the two being that a few of the quantities given in the former are omitted in the latter, and that the headings of some of the columns differ. We shall illustrate our remarks with a practical example, assuming the observation to be made on the evening of April 10, 1916, for an observer using Eastern Standard Time.

The *American Ephemeris* is computed for Greenwich Mean Noon, which for this observer occurred April 10 at 7 A. M., or as the astronomer records it on April 9, 19^h. It would be much more convenient for everyone if the ephemeris were computed for Greenwich Midnight, or 7 P. M., April 10, and it is hoped that this change may be made in the near future, as was done some years ago by the *British Nautical Almanac*. It is very desirable in making drawings of Mars to have a disk properly outlined on paper, the gibbous shape being correctly shown, and the positions of the poles marked, before any attempt at sketching the details is made.

We shall assume the scale of the drawing to be three millimeters or one-eighth of an inch to 1″. It is unfortunate as shown in our Report No. 10, that the angular diameter of Mars as given in the Ephemeris is appreciably too large. We understand it will be changed before long, and we hope back to the correct value until recently given in the *British Nautical Almanac*. We shall assume that our drawing will be made at about seven o'clock in the evening. This will be 12^h after Greenwich Noon. The diameter given for April 10 is $10''.10$ and for April 12, $9''.93$. Interpolating for 12^h gives us the diameter $10''.06$. To correct the error in the Ephemeris, we divide by 13.6 and subtract the quotient from $10''.06$, which gives us the true diameter of Mars at that time as $9''.32$ We accordingly draw one or more circles having diameters of three times this, or 28.0 millimeters.

On account of cloudy weather the drawing may not be made on the date for which the outline has been drawn, but the changes occurring in a day or two are of little moment. For this reason in drawing the preliminary outline it is not really necessary to interpolate, although this is done in the description in order that it should be theoretically correct. In the computation of all quantities determined after the drawing is completed however interpolation should be used.

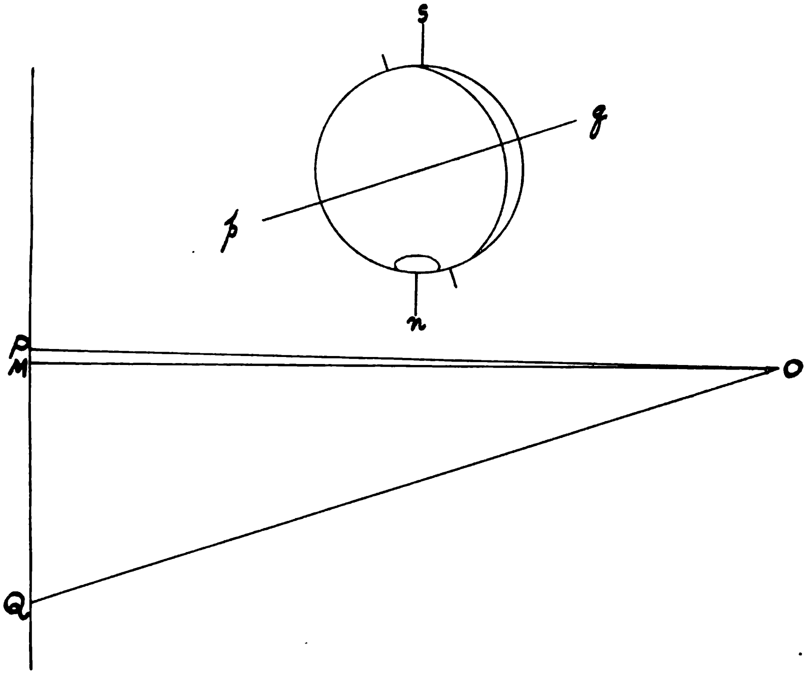


FIGURE 1.

It is the custom of the writer to enter all his drawings on the right hand page of a record book, which is ruled in horizontal lines, with a vertical line at the left hand side. The drawing is centered on one of the horizontal lines and the circle drawn. On one of the lines beneath it, we lay off a distance of 100 millimeters, from the vertical line to the point *O*, Figure 1. Turning to the ephemeris under the column headed *P*, we obtain by interpolation for our date, the angle 359°.0. Under column Q we obtain 107°.7, subtracting 90° gives us 17°.7. Laying off the natural tangents of those angles on the vertical line, we obtain +1.7 mm and − 31.9 mm. The directions are determined by the description given in the Almanac. Two long lines s and n are drawn perpendicular to OP. and two short lines perpendicular to OQ. These lines if prolonged would pass through the center of the circle.

Turning to the ephemeris under q we obtain the angle 0″.86 which is so small that we need not trouble to correct it for the error of the angular diameter. Multiplying by 3 we lay off for the phase the distance 2.58 mm on the line pq drawn parallel to OQ. If we take a radius slightly larger than that of the circle, in this case 15.0 mm, and draw an arc through this point, and centered on the line pq, we shall obtain a close approximation to the arc of an ellipse. The length of this radius is most simply obtained by trial The phase drawing is now complete, but when a series of drawings are being made, it is a good plan to copy in the snow cap from one of the previous drawings before beginning to work. This saves time at the telescope, and if it is incorrect, it is a simple matter to correct it. The method employed in making the drawing is described in full in Report No. 9, and need not therefore be repeated here. At the top of the page we record the date, and beneath the figure the times of beginning and ending the drawing of the outlines, also the time required for the shading, the magnification, quality of the seeing, and also the aperture, when a change from that usually employed occurs. These observed data we record in pencil, and the computed results in ink.

To the mean of the times given for the drawing of the outlines we add 5^h to reduce to Greenwich Time, and multiply by $r = 14°.62$, the mean rotation of Mars in one hour.

TABLE I.

Multiplication Table for r.

1	14°.62	4	58°.48	7	102°.34
2	29.24	5	73.10	8	116.96
3	43.86	6	88.72	9	131.58

Table I will be found useful when much multiplication is involved. Adding this result to 158°.11 given in the Ephemeris under Central Meridian, gives us the central meridian of the drawing. The latitude of the central point, + 15°.8, is taken from column D⊕. The inclination of the pole towards the Sun, + 23°.5, is taken from column D⊙, and the longitude of the Sun as seen from Mars, 78°.6, is given in the column ⊙ ♂. The three corresponding columns in the British Nautical

Almanac are headed B, *B*, and ⊙. Taking the last number, and turning to Report No. 10, Table I, column 2, we find in the next column the Martian Date June 2.

These results give all the facts that it is necessary to record regarding any drawing. We may however want to know at what time we should make a drawing in order that a certain longitude should be on the central meridian. Drawings are made here in every 30° of longitude, beginning at 0°. Let us suppose we wished to know when longitude 330° would be central. We look out 330° in Table II and find against it $22^h\ 34^m.2$.

TABLE II.

Times of Transit for Selected Meridians.

Merid.	Hour		Merid.	Hour		Merid.	Hour	
°	h	m	°	h	m	°	h	m
30	2	03.1	150	10	15.6	270	18	28.0
60	4	06.2	180	12	18.7	300	20	31.1
90	6	09.4	210	14	21.8	330	22	34.2
120	8	12.5	240	16	24.9	360	24	37.4

Turning to the Ephemeris, in the last column under Mean Time of Transit of Zero Meridian, we find for April 10, $13^h\ 49^m.0$. If we should add this to the number taken from our table, the result would be greater than 24^h. We must therefore go back to the previous date. This gives us $13^h\ 10^m.8$. Adding the numbers now gives us $35^h\ 45^m.0$ on April 9, or April 10, $11^h\ 45^m.0$ G.M.T. Subtracting 5^h to correct to Eastern Standard Time gives us $6^h\ 45^m.0$ as the required result.

In the above computations the rate of rotation 14°.62 has been taken as a constant. This is not strictly true, but its limiting values in any case likely to occur in practice may be taken as 14°.60 and 14°.64. This would give a maximum error of 0°.5 for the longitude of a drawing, and of 2^m in the time of transit. The maximum value 14°.64 is only reached at aphelion oppositions, as we then pass Mars more rapidly than we do at perihelion, when it is nearer to us. This at first seems strange, but is accounted for if we recollect that at perihelion Mars is moving more nearly at the same speed as the Earth, so that we stay with it longer. The minimum value 14°.60 is attained when the planet is remote from us, and when very remote and at too great a distance to observe, a still smaller value is reached.

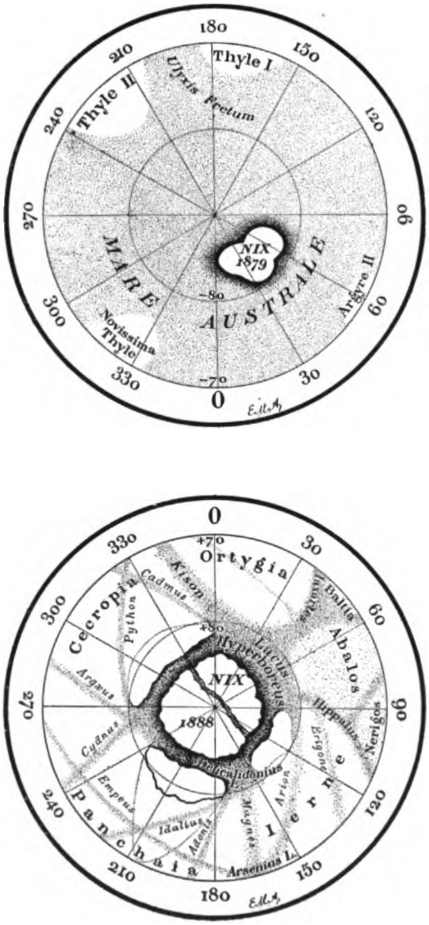
It may be of some interest to the amateur to know what can be seen on Mars with a small telescope. With our 3-inch finder, and a power of 180 on February 27, seeing 5, the Acidalium marsh and the southern maria were both conspicuous. They were also visible with a power of 90. The northern polar cap could be seen with more difficulty. On February 3 the Syrtis and the canals Thoth and Nilosyrtis were clearly seen. By April all these features will be more difficult, and it is probable that the polar cap will be too small to be visible. We should look at 9^h Eastern Standard Time, or 8^h Central, on or about April 7 for Acidalium, and about April 17 for the Syrtis and the canals. In Report No. 8, Figures 2 and 9 will give an idea of the appearance of the former region, and Figures 22 and 23 of the latter.

We are happy to be able to refer our readers in the future to the excellent map of Flammarion and Antoniadi, published herewith, (Plates XI and XII) which gives many features not contained in that of Schiaparelli, is on a much more convenient projection, and has the great advantage over many maps that have been published of the planet, that it is exceedingly clear, in spite of the fact that the canals are very numerous in certain regions. The type is everywhere sufficiently large to be read, yet is nowhere so obtrusive as to hide the topographical features.

As was shown in our Report No. 9, for all solar longitudes ⊙ exceeding 34°.1, which was passed January 2, 1916, the planet is seen to better advantage at the present opposition than at the last one. During the past winter we have had fewer favorable nights than usual in Jamaica, and these were mostly occupied in making drawings of the planet, a few topographical positions however have been determined. The shifting to the west, that is to higher longitudes, of the Twin Polar Bays has been confirmed. In Report No. 14 a measure is given, made on December 8 of the south preceding end of Castorius, the preceding of the two bays. Its longitude was 135°.6. Two days later we found it 137°.5. Mean 136°.6 ± 1°.0. On January 15 it was 151°.1, and on February 19 practically the same, 151°.8. Mean 151°.4 ± 0°.4. Shift 14°.8. The longitude according to the map is 155°. There is very little water in it now as compared to the previous opposition. It is faint and difficult to see, much more so than last December, and presumably it has dried up. Therefore its advance has practically ceased. In a report just received from Professor Lau in which he writes of a drawing recently sent me, he says it shows Charontis, but that the "details (Phlegra, Propontis) are evidently strongly displaced." Propontis is the companion twin bay.

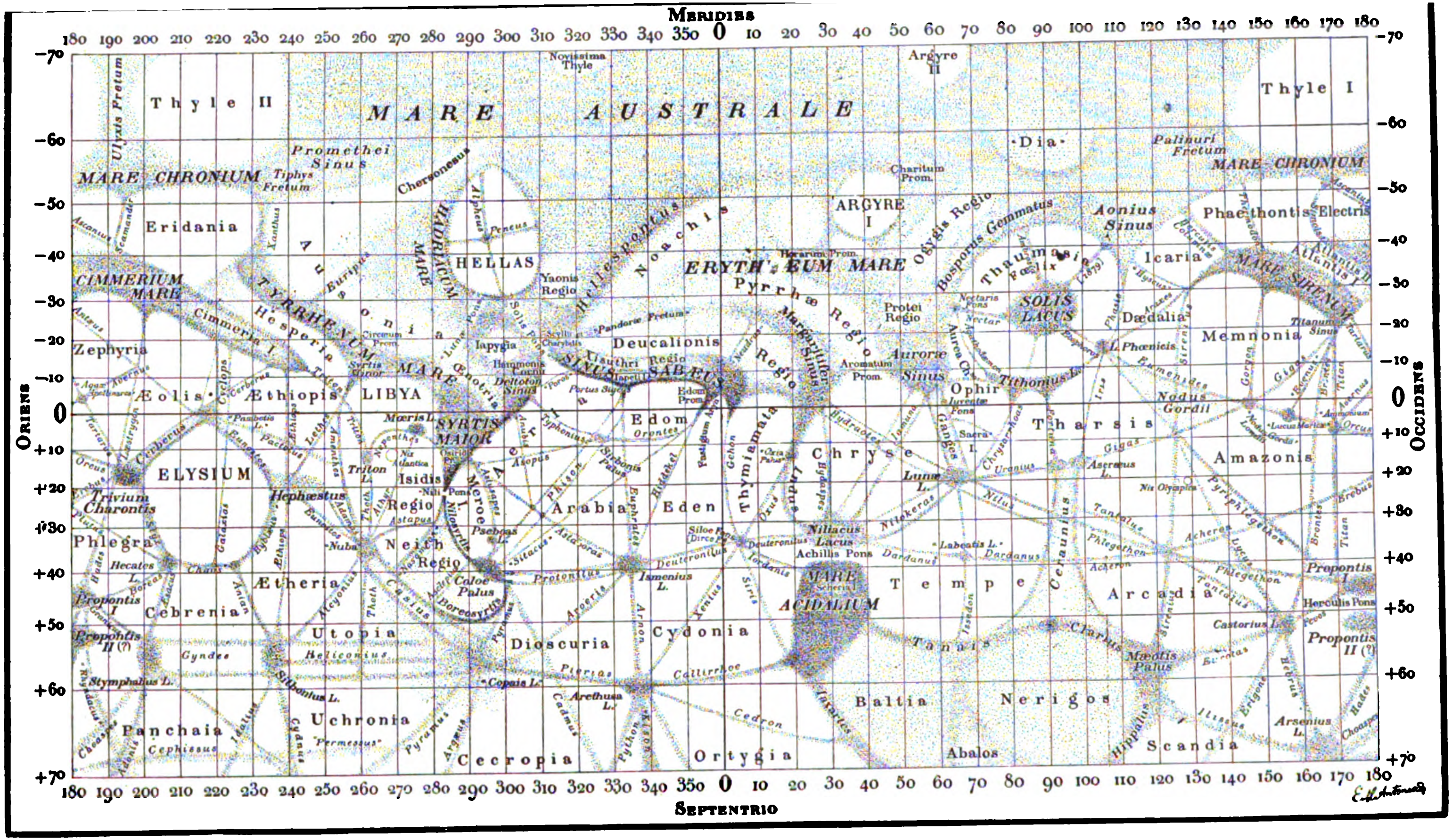
The position of the southernmost point of Acidalium, known also as Niliacus, was determined February 27, 28, and March 1. Longitudes 33°.9, 37°.3, 36°.9, mean 36°.0 ± 1°.4. Latitudes + 26°.1, + 26°.2, + 23°.2, mean 26°.5 ± 1°.1. Its position according to the map is in longitude 30°, latitude + 28°. The position of Nodus Gordii was determined November 4. It was found to be located in longitude 131°, latitude + 25°. Report No. 13. On account of its unusual northern latitude however, it was not recognized at that time. Its position was again determined January 16, longitude 123°.2, latitude

PLATE XI



Charts of the North and South Polar Areas of Mars

From "La Planète Mars" Tome II.



GENERAL CHART OF THE PLANET MARS BY FLAMMARION AND ANTONIADI

From "La Planète Mars" Tome II.

+18°. According to the map its mean longitude is 126°, and its latitude + 9°. We are very certain of the accuracy of our result in January, because owing to the inclination of the planet's axis, the point measured lay in the exact center of the disk. This seems to be a clear case of shift in latitude. By the time it was due to be seen in February, it had completely faded out. In the light of this shifting of details, it is now seen that the second drawing in Figure 2 of Report No. 5 refers to the Nodus Gordii, and not to Sirenum. The position there determined was in longitude 143°, latitude + 9°. This is not far from Lowell's position as given on the map, 146° and +1°.

The longitude of Thoth in latitude + 30° was determined February 2 as 261°.2 and February 3 as 256°.7. Mean 259°.0 ±2°.2. This seems rather a large deviation, 80 miles, and the measure should be repeated. According to the map the longitude is 262°. In this connection it may be mentioned that this canal is really Thoth, and not Amenthes as has been suggested by some. Amenthes is connected with Nilosyrtis by the Tyrrhenum Mare in latitude —10°. Thoth is connected with it by Nepenthes in latitude + 5°. The latitude of the connecting canal was measured on a drawing made February 2, ω 270°.8. Where the canal crossed the central meridian its latitude was + 6°.4. It is therefore Nepenthes, and the canal in question Thoth.

Three determinations have been made of the position of Titanum. December 8 its longitude was 156°.2, January 15, 155°.4, and February 19, 157°.7. Mean 156°.4 ± 0°.8. According to the map it is 170°, a difference of 13°.6. This is equivalent to 500 miles! The latitudes on these three dates were − 22°.9, − 18°.7, and − 22°.5. Mean −21°.4 ± 1°.8. According to the map its latitude is −20°. Difference 50 miles. An examination of the drawings confirms this shift, and makes it clear that Titanum has certainly moved away from Elysium. On our drawings of February 7, 9, and 12 it was also clear that the large bay similar to Titanum which was visible at the last opposition, had reappeared at the mouth of Laestrigon. In Report No. 5 we found evidence of a considerable shift in the longitude of Titanum, ranging from 162° early in the season, to 175° towards the end. Titanum was one of the points suggested for general observation this year in Report No. 13, and it is hoped that it may have been located by some other observer.

Certain of the more accessible Associates have been notified by mail of these observations, with the request that they be repeated. Their main importance lies in the fact that if the more conspicuous features of the planet shift about over its surface indiscriminately, no determination of the period of rotation based on observations of a single feature, continued through the period of the few years of any one man's observing life should have much weight, but for the present we must still depend on a comparison of our results with the earliest recognizable drawings of the planet.

Another point of importance is that if the canals shift laterally through several hundred miles, it is useless to make maps covered with scores of canals located only a few miles apart, and only a few of which are seen at any one time. It would obviously be idle to give the Syrtis canal one name on Dr. Lowell's map, to give it another on that of Mr. Lau, and to give it still a third in the present investigation. About 800 canals have now been named. It is better to confine ourselves to perhaps a hundred names, such as are shown on the present map, rather than burdening our memories with the names and locations of 700 minor canals, which would be of no particular importance, even supposing that they had a separate individual existence. As an example of what is proposed, it may be mentioned that on February 12 a new canal appeared joining Cerberus, and lying between Antaeus and Tartarus, neither of which was then visible. Instead of giving it a new name, it is proposed in such a case to designate it simply as [Tartarus-Antaeus]. Should all three canals appear later at once, which is very unlikely, it might then be time to change the designation of the present one.

A few exceptions to this rule may be necessary. Thus it is clear that the little canal recorded in 1913-14 joining Juventae to Aurorae was not identical with Ganges, and might very well appear at the same time with it. In his map of 1896 Lowell shows two small canals Baetis and Hebe connecting with Juventae. In Report No. 8, Figures 6 and 8, the canal shown coincides most nearly with Baetis. This name will therefore be adopted hereafter to designate it. This is the only instance hitherto recognized where it seems necessary to go outside of the present map for a name.

On January 23, ω 27°.6, M. D. April 39, Margaritifer appeared here for the first time this opposition. It was certainly invisible December 20 and 25, M. D. April 6 and 11. It was now well developed, and quite dark. Sabaeus was also clearly seen. Its southern boundary was beginning to take form, but its western end was still quite undeveloped. The next night both were well marked, but it was only on January 30 that its whole outline was complete and strongly defined. No trace of Aryn had yet appeared, 343°.7, corresponding M.D. April 45. Neither was it seen on February 28, ω 30°.4, M.D. May 18. It was suspected however two nights later, and in a few days became clearly visible. In the light of the lateness of its appearance at the present opposition, and my inability to see it at all at the previous one, even when carefully looked for, I cannot believe that it was visible at that time, although shown in the Martian months of March and April by several other observers.

On January 23 was also recorded the first appearance of brown supposed on the green of the southern maria, to the south of Margaritifer and Aurorae. Although this was the latter part of April on Mars, we must remember that we are now dealing with their southern hemisphere, so that it is their autumn of which we are speaking. The first greens were detected on the planet at this opposition on February 44, in this same region, Report No. 12, so that their duration was 107 days, or three and a half of our months.

In our last Report, for December, we called attention to the gradual drying up of the Syrtis marsh since its first appearance on October 23, and found that our observations were confirmed by Professor Douglass on the nights of November 28 and December 3. A report and drawing recently received from another Associate, Mr. W. F. Gale, in Australia further confirms this statement, and shows that on December 12 the northern tip of the Syrtis was appreciably *lighter* than regions further south, the darker regions lying along the western side, and extending only to latitude + 10°. Its color was grey, the polar sea being a light steel blue at the time. He was much impressed by a brilliant cloud immediately following the Syrtis when near the limb, and which later dissolved, exposing the intense red of the desert regions in its place. On December 26 we recorded that there was no evidence whatever of the Syrtis marsh.

Five days later, January 1, the marsh and polar sea were both conspicuous, bright blue, and equally dark. The marsh was the bluer of the two, and its eastern side was lighter and bluer than the western. No observations were possible here during this interval, and as far as heard from in response to the query in our last Report, no observations seem to have been made in the United States between December 26 and January 1. If such is the case it is regrettable, since this region could not have been well seen in Europe during this period. It was suggested in Report No. 9 that changes on Mars in the region of the Syrtis might be expected during these months, and the dates when it could be well seen were computed and indicated in Table I, in order to aid would be observers.

Although on our drawing of January 1, Casius, usually a very dark marking, must have stretched from within 15° to 35° from the central meridian, on the side of the terminator, yet it was not recorded. The whole surrounding region was extremely dark. On our next drawing January 4, ω 270°, Casius is shown, but it was no darker than its continuation Thoth, and it looked as if it might have been drained of its superfluous moisture to fill the Syrtis. The next night it was much darker, and appeared to have partially recovered. In a note to the writer Mr. Lau speaks of the invisibility of Casius in a "preceding observation", made presumably in December. The maria preceding the Syrtis were now distinctly green.

When next seen, January 30, the marsh was still bluish, and this color was retained until February 4, but three days later it had disappeared. A projection of the marsh into Nepenthes was formed between January 30 and February 2, and a dark extention to the west of the northern tip, blunting it, and yet further increasing its longitude appeared February 2. A very large but much paler extension further south, and probably brownish in color reaching 1000 miles to the eastward also appeared. Its length was further increased by 500 miles the next night, and at the same time the southeastern end of the marsh retreated several hundred miles. Presumably it dried up. A special drawing was made to indicate this change, which was quite marked. This was confirmed two nights later, when the marsh appeared still smaller, but by February 9 and again February 11 was as large as ever.

On February 4, M. D. April 50, the planet was compared with the colored sketch Figure 1 shown in November number of POPULAR ASTRONOMY, and distributed in connection with the Index to the first ten reports. The sketch was illuminated by a 9 c. p. tungsten lamp shining through a blue medium, of such density that the snow of the planet appeared of the same tint as the white paper. The magnification employed was 660, and the aperture was reduced to five inches, so that the planet and the colored sketch appeared of the same brilliancy. It was recorded that the snow, deserts, and south polar regions were now correct, the greens, and Syrtis were of the proper darkness, and with good seeing of very nearly the right color, though possibly a trifle too green. The better the seeing, the greener they appeared.

Two nights later the maria were recorded as grey not green, and the next night as brown, like the maria south of Acidalium, seeing 9. This color we take, as above suggested to be a ripening of vegetation, analogous to the change of leaf in our fall. By February 9 the brown area had reached the junction of Laestrigon, some 3000 miles from its origin at the Syrtis, the mean rate of travel having been something like 300 miles per day. This termination of the season on Mars seems to be a very sharply marked phenomenon, which should be looked for in future years. It appears to be even more distinct than the first appearance of the greens previously noted. There seemed to be a similar brown extension starting westerly from the Syrtis, but when last seen February 11 it had not progressed very far. If really due to a change of leaf, it would indicate that in latitudes − 10° to −30° the frosts came this year between April 39 and 53, or in what would correspond with us to early November. Compare the third and fourth columns of the Calendar, Report No. 10. A similar change occurs in our northern New England States in latitude + 45° about the last of September. In latitude 20° on the Earth there is of course no change of leaf.

The south polar regions throughout the whole of this period appeared of a greenish yellow, but it is believed that yellow was more nearly its true color, and that the green was mainly a contrast effect. The clouds frequently seen in Elysium following Charontis, Styx, and Cerberus, and also those seen following Thoth and Nilosyrtis, indicate to us that these canals are all of the same nature as Acidalium, which is always followed by a cloud. In other words they seem all to be of a marshy character, rather than canals due to vegetation. Indeed on one occasion it was thought' that faint traces of polarization were detected in Nilosyrtis. These clouds sometimes persist all the way across the face of the planet, but usually they disappear or are very faint after noon.

On February 7, ω 232°, there was a bright cloud filling the space between Thoth and Nilosyrtis, but two hours later it had vanished and the intervening space was unusually dark, brightness 5, giving the impression of moistened ground, as if there had been rain. Irrespective of the latitude, — 20°, thawing does not seem likely under the conditions observed, while rain seems a possible explanation. These cloud changes sometimes take place with great rapidity. Thus on February 12, ω 172°, there was a large cloud on the limb following Nilosyrtis, reaching as far as the southern maria, and covering 0.12 of the whole disk. Within half an hour the northern two-thirds of this cloud had entirely vanished. This cloudy region must have covered 2,000,000 square miles of surface. These clouds frequently stop at the edge of the maria.

Another comparison with the colored print was made February 25, ω 46°, M. D. May 15. The deserts of the print were now not quite red enough, and the marsh clearly not as blue as on the planet. The greens on Mars had now faded completely, and were replaced by a brownish grey tint. It may be noted here that the brown in Figure 2 is too intense and the greens, rather too blue. It is unfortunate that our forwarding agent was unable to send us a torch capable of holding a 9 c. p. lamp before the end of January, so that no satisfactory measures were possible at the beginning of the Martian season, but some made with a lamp of 2 c. p. indicate that the greens shown in the two sketches were then very nearly correct. There is some evidence that Acidalium is now drying up, and losing its blue color.

Two more reports, illustrated in colors, have been received from our Associate Mr. McEwen, extending from November 1 to December 25. His source of illumination is a lamp burning cycle lamp oil, which at 4 c. p. and at a convenient distance, renders the paper slightly brighter than the planet. Although the writer uses the white filament of a tungsten lamp, rendered still more blue by blue glass or blue gelatin film, until its color approximates that of daylight, yet both observers agree closely as to the color of the desert regions of the planet. At certain times appear rather less red to the writer, at others we exactly agree. This is rather surprising, since we should naturally suppose that a bluer illumination would require a redder pigment. It is only when we come to the greens and blues that a notable difference appears in our results. To Mr. McEwen these regions usually appear brown or greyish. He uses colored crayons in preference to water colors, as the writer does in part, Report No. 9, and the tint he most frequently mentions is gold ochre. He also mentions light and brown ochre, burnt and brown yellow, raw umber, sepia, Van Dyke brown, and Venetian red.

Some of his more interesting observations follow. On November 3 Acidalium was on the central meridian, color raw umber. It was very faint, and not nearly so dark as Aurorae. This is certainly unusual, and can only be explained by heavy cloud over the marsh. He mentions particularly the bright white cloud following it. Margaritifer and Aurorae appeared as a dark band, that is to say the former had not yet developed as a bay. This is further confirmed November 10, when he records Protonilus, Ismenius, and Deuteronilus all prominent, and much darker than Sabaeus or Margaritifer, which later appeared as a faint band stretching across the southern part of the disk. A small white spot, [i.e. a cloud] was visible at the center of the disk $\lambda\, 354°$, $\delta + 20°$. November 19 Syrtis Major was very faint when nearly half way to the center, and not so dark as Nilosyrtis or Boreosyrtis. This further confirms the drying up of the Syrtis at this period, following its first inundation in October.

December 12. Hiddekel and Gehon were seen together as a very faint broad and diffused band extending from the bay of Sabaeus towards Ismenius and Dirce. This is the broad north and south band to which frequent reference was made in our earlier reports. Sabaeus bay was distinct, of triangular shape, with a sharp northern boundary. Aryn had therefore not developed by that date. The bay was less distinct an hour later, when it had passed the central meridian. The southern edge of Thymiamata, Chryse and Ophir appeared as a white line, lying in an east and west direction. Margaritifer therefore had not yet developed. We have just seen that it did not appear in Jamaica as a bay until six weeks later, January 23.

Table III contains the usual data of the month's drawings.

TABLE III.

DATA OF THE DRAWINGS.

No.	1916	⊙	M. D.	Long.	Lat.	Sun	Diam.	Seeing
42	Jan. 1	35°.1	Apr. 17	295°	+19°	+14°	11".4	5, 4
43	" 4	36.4	" 20	270	"	"	11.7	5, 4
44	" 5	36.9	" 21	242	"	"	11.8	6
45	" 12	40.0	" 28	203	"	15	12.4	5
46	" 15	41.4	" 31	155	18	16	12.7	8, 10
47	" "	"	" "	180	"	"	"	8, 7
48	" 16	41.7	" 32	92	"	"	12.8	8, 9
49	" "	"	" "	117	"	"	"	8, 9
50	" 17	42.1	" 33	66	"	"	"	8, 7
51	" 23	44.8	" 39	28	"	17	13.3	6, 7
52	" 24	45.2	" "	7	"	"	13.4	7, 6
53	" 30	47.9	" 45	314	17	18	13.7	6, 7
54	" "	"	" "	344	"	"	"	9
55	" 31	48.3	" 46	297	"	"	"	6, 8
56	Feb. 2	49.2	" 48	271	"	"	13.8	8, 7
57	" 3	49.6	" 49	258	"	"	"	10
58	" 7	51.4	" 53	242	16	"	13.9	9
59	" 9	52.3	" 55	216	"	19	"	8, 6
60	" "	"	" "	310	"	"	"	4
61	" 12	53.6	May 2	179	"	"	13.8	10
62	" "	"	" "	268	"	"	"	5
63	" 19	56.6	" 9	120	15	20	13.6	8, 7
64	" "	"	" "	153	"	"	"	7, 6
65	" 24	58.8	" 14	90	"	"	13.3	6, 7
66	" "	"	" "	126	"	"	"	6, 6
67	" 26	59.7	" 16	61	"	"	13.2	7

The following canals and lakes were seen:—

Jan. 1 F Nilosyrtis.

Jan. 4 F Nilosyrtis, Thoth, Astusapes.

Jan. 5 E Nilosyrtis, Thoth, Astusapes, Casius, Hephaestus, Eunostos, Cyclops, Cerberus, Styx, Chaos, Hyblaeus, Aesacus.

Jan. 12 D Casius, Cyclops, Cerberus, Chaos.

Jan. 15 D Eunostos, Cyclops, Cerberus, Chaos, [Tartarus-Antaeus], Brontes, and Nodus Gordii.

Jan. 16 C Brontes, Tantalus, Sirenus, Acheron, Tithonius, Eosphoros, Nectar, Ceraunius, Nilokeras, and Phoenices, Solis, Lunae.

Jan. 17 B Ceraunius, Nilokeras, Ganges, Tithonius, Nectar, and Solis, Lunae.

Jan. 23 A Nilokeras, Ganges, Tithonius, Nectar, Indus.

Jan. 24 A Deuteronilus, Protonilus.

Jan. 30	**FA**	Protonilus, Nilosyrtis, Thoth, Casius, Indus, Oxus, Deuteronilus, Sitacus, and Ismenius, Moeris.
Jan. 31	**F**	Deuteronilus, Arnon, Protonilus, Astusapes, Nilosyrtis, Nepenthes, Thoth, Casius, and Ismenius.
Feb. 2	**F**	Protonilus, Nilosyrtis, Nepenthes, Thoth, Casius, Hephaestus, Cyclops, Eunostos, Hyblaeus.
Feb. 7	**E**	Nilosyrtis, Nepenthes, Thoth, Casius, Hephaestus. Eunostos, Cyclops, Cerberus, Hades, Styx, Aesacus, Chaos, Hyblaeus.
Feb. 9	**EF**	Nepenthes, Thoth, Casius, Hephaestus, Eunostos, Cyclops, Cerberus, Erebus, Hades, Chaos, Hyblaeus, Protonilus, Nilosyrtis.
Feb. 12	**DE**	Eunostos, Cyclops, Cerberus, Tartarus, Laestrigon, Avernus, Styx, Chaos, Hyblaeus, Hades, Erebus, Nilosyrtis, Nepenthes, Thoth, Casius.
Feb. 19	**CD**	Tantalus, Acheron, Ceraunius, Cerberus, Hades, Erebus.
Feb. 24	**C**	Acheron, Ceraunius, Nilokeras, Tithonius, Iris, Fortuna, Nectar, Ganges, Tantalus, and Solis, Tithonius.
Feb. 26	**B**	Ceraunius, Nilokeras, Tithonius, Fortuna, Nectar, Bosporus, Ganges, and Solis, Tithonius, Lunae.

These canals except Astusapes were all broad, often several hundred miles in width, never less than one hundred. As a rule they were curved rather than straight. With the coming of March a different type of canal appeared, both narrow and straight. No duplications have hitherto occurred, but with the coming of the new type new phenomena may appear.

ARCTURUS—RISING.

Again Arcturus beams!—his gleaming light
Burns brilliantly amidst the star-lit night,
Like harbinger in yonder eastern sky
He rises to proclaim that spring is nigh;
When winter's snow still lies on hill and vale,
And winds of March first wander down the dale,
Ere crocus blooms or falls mild April's rain,
Like beacon bright Arcturus beams again.

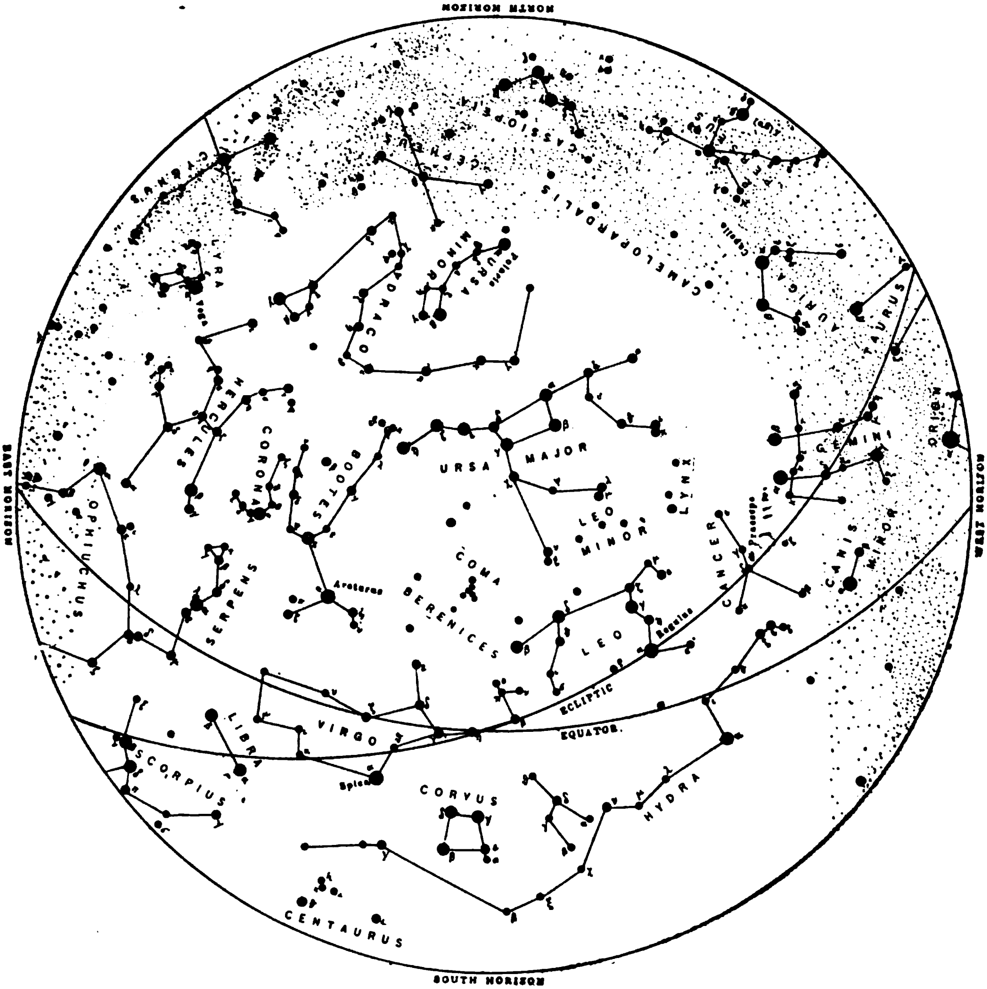
CHARLES NEVERS HOLMES.

Newton, Mass.
41 Arlington St.

PLANET NOTES FOR MAY, 1916.

Clifford C. Crump.

The sun will move during the month by a northeasterly course from Aries into Taurus. About the middle of the month it will be near the region of the Pleiades.



The Constellations at 9:00 p. m. May 1.

The phases of the moon for this month are as follows:

New Moon	May 1	at	11	P.M.	C.S.T.
First Quarter	10	"	3	A.M.	"
Full Moon	17	"	8	A.M.	"
Last Quarter	23	"	11	P.M.	"
New Moon	31	"	2	P.M.	"

Mercury will continue its eastward motion from the sun until May 27. It will then move in a retrograde direction for the remainder of the month. It will not be in a favorable position for observation.

Venus will be in a good position for observation during the month. It will pass from the constellation of Taurus into the constellation of Gemini.

Mars will have an easterly motion and move from the constellation of Cancer into the constellation of Leo. It will cross the meridian early in the evening.

Jupiter will appear in the morning sky in the constellation of Pisces.

Saturn will continue to be visible in the early evening low in the western sky in the constellation of Gemini.

Uranus may be seen in Capricornus in the early morning.

Neptune will be visible in the early evening in the constellation of Cancer a few hours east of Saturn.

Occultations Visible at Washington.

Date 1916		Star's Name	Magnitude	IMMERSION.			EMERSION.			Duration	
				Washington M.T.		Angle f'm N.	Washington M.T.		Angle f'm N.		
				h	m	°	h	m	°	h	m
May	8	θ Cancri	5.5	10	43	66	11	21	345	0	37
	19	86 B Sagittarii	6.5	10	49	158	11	14	202	0	25
	20	53 Sagittarii	6.3	13	53	121	14	45	204	0	52
	20	274 B Sagittarii	6.1	14	6	129	14	49	195	0	43

Mars at the Opposition 1915-16.—The following notes concerning the planet Mars have been received as Observation Circulars from Professor Percival Lowell, director of the Lowell Observatory:

Flagstaff, Arizona
March 8, 1916.

"The Martian canals in the region Aeria, from forty degrees north latitude to six degrees south latitude, the Euphrates, Phison and others, at present observed near the center of the disk, have darkened appreciably since the last presentation five weeks ago, showing the quickening effect from the north polar melting."

Flagstaff, Arizona.
March 9, 1916.

"The frost on Hellas, the mid-latitude of which is forty-five degrees, where the South Polar Cap is now in process of forming, diminished strikingly between the evenings of March 7th, and 8th. The season in the northern hemisphere of Mars now corresponds to November 26th on the earth."

Flagstaff, Arizona.
March 14, 1916.

"Canals in Mare Erythraeum have faded out since its last presentation. The Mare is now a light chocolate tint in contrast to blue-green markings elsewhere. Martian season in southern hemisphere corresponds to November 27th."

VARIABLE STARS.

Approximate Magnitudes of Variable Stars of Long Period on Mar. 1, 1916.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.		Decl. 1900.		Magn.	Name.	R.A. 1900		Decl. 1900		Magn.
	h	m	°	′			h	m	°	′	
X Androm.	0	10.8	+46	27	10.0 *i*	W Aurigae	5	20.1	+36	49	13.3
T Androm.		17.2	+26	26	13.4*d*	S Aurigae		20.5	+34	4	8.4 *i*
T Cassiop.		17.8	+55	14	8.6	S Orionis		24.1	— 4	46	11.1*d*
R Androm.		18.8	+38	1	14.2*d*	S Camelop.		30.2	+68	45	10.3*d*
Y Cephei		31.3	+79	48	11.2*d*	T Orionis		30.9	— 5	32	10.0
U Cassiop.		40.8	+47	43	14.0*d*	U Aurigae		35.6	+31	59	14.0*d*
RW Androm.		41.9	+32	8	13.7	SU Tauri		43.2	+19	2	9.5
V Androm.		44.6	+35	6	13.0*d*	Z Tauri		46.7	+15	46	14.0*d*
RR Androm.		45.9	+33	50	14.5*d*	RU Tauri		46.9	+15	57	13.1
RV Cassiop		47.1	+46	53	14.5*d*	V Camelop.		49.4	+74	30	10.8*d*
W Cassiop.		49.0	+58	1	9.5 *i*	U Orionis		49.9	+20	10	11.1 *i*
Z Ceti	1	1.6	— 2	1	9.5 *i*	Z Aurigae		53.6	+53	18	10.0
U Androm.		9.8	+40	11	13.0*d*	X Aurigae	6	4.4	+50	15	12.1*d*
UZ Androm.		10.4	+41	12	12.5 *i*	SS Aurigae		5.8	+47	46	<13.5
S Cassiop.		12.3	+72	5	14.4*d*	V Aurigae		16.5	+47	45	11.2*d*
S Piscium		12.4	+ 8	24	9.8*d*	V Monoc.		17.7	— 2	9	9.0*d*
U Piscium		17.7	+12	21	11.0*d*	U Lyncis		31.8	+59	57	12.8
RZ Persei		23.6	+50	20	12.4 *i*	S Lyncis		35.9	+58	0	12.4*d*
R Piscium		25.5	+ 2	22	13.0*d*	X Geminorum		40.7	+30	23	12.8
RU Androm.		32.8	+38	10	14.0*d*	W Monoc.		47.5	— 7	2	11.8*d*
Y Androm.		33.7	+38	50	14.0*d*	Y Monoc.		51.3	+11	22	12.9*d*
X Cassiop.		49.8	+58	46	10.8 *i*	R Lyncis		53.0	+55	28	8.3
U Persei		53.0	+54	20	8.5*d*	R Geminorum	7	1.3	+22	52	11.7*d*
S Arietis		59.3	+12	3	11.7 *i*	V Can. Min.		1.5	+ 9	2	<14.0*d*
R Arietis	2	10.4	+24	35	8.4 *i*	R Can. Min.		3.2	+10	11	10.0
W Androm.		11.2	+43	50	8.7 *i*	RR Monoc.		12.4	+ 1	17	10.5 *i*
Z Cephei		12.8	+81	13	10.0 *i*	V Geminorum		17.6	+13	17	<13.0
o Ceti		14.3	— 3	26	5.1*d*	S Can. Min.		27.3	+ 8	32	9.5*d*
S Persei		15.7	+58	8	8.7	Z Puppis		28.3	—20	27	<13.5
R Ceti		20.9	— 0	38	11.0*d*	T Can. Min.		28.4	+11	58	13.0*d*
RR Persei		21.7	+50	49	13.7*d*	U Can. Min.		35.9	+ 8	37	8.4
U Ceti		28.9	—13	35	12.0*d*	S Geminorum		37.0	+23	41	13.5 *i*
RR Cephei		29.4	+80	42	9.8 *i*	T Geminorum		43.3	+23	59	13.2*d*
R Trianguli		31.0	+33	50	5.4 *i*	U Geminorum		49.2	+22	16	<13.5
W Persei		43.2	+56	34	10.0	U Puppis		56.1	—12	34	14.0
U Arietis	3	5.5	+14	25	9.0 *i*	R Cancri	8	11.0	+12	2	9.2 *i*
X Ceti		14.3	— 1	26	11.3*d*	V Cancri		16.0	+17	36	8.2
Y Persei		20.9	+43	50	9.5	RT Hydrae		24.7	— 5	59	8.0
R Persei		23.7	+35	20	12.8 *i*	U Cancri		30.0	+19	14	13.5*d*
T Eridani		51.0	—24	20	8.0	X Urs. Maj.		33.7	+50	30	<13.0
W Tauri	4	22.2	+15	49	9.0	S Hydrae		48.4	+ 3	27	10.5*d*
R Tauri		22.8	+ 9	56	13.8	T Hydrae		50.8	— 8	46	10.0*d*
S Tauri		23.7	+ 9	44	14.8	T Cancri		51.0	+20	14	9.5
T Camelop.		30.4	+65	57	9.1 *i*	S Pyxidis	9	0.7	—24	41	13.0*d*
X Camelop.		32.6	+74	56	9.5 *i*	W Cancri		4.0	+25	39	12.5 *i*
RX Tauri		32.8	+ 8	9	11.5*d*	X Hydrae		30.7	—14	15	8.5 *i*
V Tauri		46.2	+17	22	13.5*d*	Y Draconis		31.1	+78	18	13.0 *i*
R Orionis		53.6	+ 7	59	10.3 *i*	R Leo. Min.		39.6	+34	58	7.8*d*
R Leporis		55.0	—14	57	9.0*d*	RR Hydrae		40.4	—23	34	11.0 *i*
T Leporis	5	0.6	—22	2	10.4*d*	R Leonis		42.2	+11	54	8.6*d*
V Orionis		0.8	+ 3	58	11.3*d*	Y Hydrae		46.4	—22	33	6.6
R Aurigae		9.2	+53	28	9.0 *i*	V Leonis		54.5	+21	44	13.0*d*

Approximate Magnitudes of Variable Stars of Long Period on Mar. 1, 1916—Continued.

Name.	R. A. 1900.		Decl. 1900		Magn.	Name.	R. A. 1900.		Decl. 1900		Magn.
	h	m	°	′			h	m	°	′	
R Urs. Maj.	10	37.6	+69	18	10.0*d*	S Librae	15	15.6	−20	2	9.0*d*
V Hydrae		46.8	−20	43	6.6	S Serpentis		17.0	+14	40	<14.0
W Leonis		48.4	+14	15	12.8	S Cor. Bor.		17.3	+31	44	7.0
S Leonis	11	5.7	+ 6	0	13.5	RS Librae		18.5	−22	33	<12.0
R Com. Ber.		59.1	+19	20	<13.0	RU Librae		27.7	−14	59	<12.0
SU Virginis	12	0.0	+12	56	12.5	S Urs. Min.		33.4	+78	58	10.0 *i*
T Virginis		9.5	− 5	29	9.5 *i*	R Cor.Bor.		44.4	+28	28	6.0
R Corvi		14.4	−18	42	8.4 *i*	X Cor. Bor.		45.2	+36	35	<13.0*d*
SS Virginis		20.1	+ 1	19	8.2*d*	V Cor. Bor.		46.0	+39	52	9.0*d*
T Can. Ven.		25.2	+32	3	10.3 *i*	R Serpentis		46.1	+15	26	8.8 *i*
Y Virginis		28.7	− 3	52	10.6*d*	Z Cor. Bor.		52.2	+29	32	<13.0
T Urs. Maj.		31.8	+60	2	12.8	U Serpentis	16	2.5	+10	12	10.0 *i*
R Virginis		33.4	+ 7	32	8.8*d*	R Urs. Min.		31.3	+72	28	9.5 *i*
RS Urs. Maj.		34.4	+59	2	12.5*d*	R Draconis		32.4	+66	58	8.5 *i*
S Urs. Maj.		39.6	+61	38	8.4*d*	RV Herculis		56.8	+31	22	11.3 *i*
RU Virginis		42.2	+ 4	42	12.3	T Draconis	17	54.8	+58	14	12.3*d*
U Virginis		46.0	+ 6	6	11.0 *i*	V Draconis		56.3	+54	53	<13.5
V Virginis	13	22.6	− 2	39	<12.0	W Draconis	18	5.4	+65	56	11.0*d*
R Hydrae		24.2	−22	46	8.0 *i*	X Draconis		6.8	+66	8	10.2
S Virginis		27.8	− 6	41	8.8*d*	SV Draconis		31.2	+49	18	12.0 *i*
T Urs. Min.		32.6	+73	56	13.5*d*	U Draconis	19	9.9	+67	7	11.3*d*
R Can. Ven.		44.6	+40	2	8.3*d*	X Cephei	21	3.6	+82	40	13.3*d*
Z Bootis	14	1.7	+13	59	12.0*d*	T Cephei		8.2	+68	5	6.5
Z Virginis		5.0	−12	50	12.0	S Cephei		36.5	+78	10	9.5
U Urs. Min.		15.1	+67	15	9.3*d*	SS Cygni		38.8	+43	8	11.8
S Bootis		19.5	+54	16	13.3*d*	S Lacertae	22	24.6	+39	48	12.8
RS Virginis		22.3	+ 5	8	<13.0	R Lacertae		38.8	+41	51	12.8*d*
R Camelop.		25.1	+84	17	9.8 *i*	V Cassiop.	23	7.4	+59	8	12.6*d*
V Bootis		25.7	+39	18	9.8*d*	Z Androm.		28.8	+48	16	8.6
R Bootis		32.8	+27	10	12.0*d*	Z Cassiop.		39.7	+56	2	<13.5
U Bootis		49.7	+18	6	10.5	RR Cassiop.		50.7	+53	8	12.6 *i*
RT Librae	15	0.8	−18	21	10.0*d*	R Cassiop.		53.3	+50	50	9.6
T Librae		5.0	−19	38	11.0*d*	Y Cassiop		58.2	+55	7	12.0 *i*
Y Librae		6.4	− 5	38	8.6	SV Androm.		59.2	+39	33	13.0

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory. from observations made by the following observers:—T. C. H. Bouton, A. B. Burbeck, L. Campbell, H. O. Eaton, W. P. Hoge, S. C. Hunter, J. B. Lacchini. O. Mach, C. Y. McAteer, C. S. Mundt, G. F. Nolte, W. T. Olcott, C. B. Lindsley, D. B. Pickering, C. F. Richter, H. M. Swartz, H. W. Vrooman, I. E. Woods, and A. S. Young,

The Spectrum of Nova Geminorum No. 2, February 1916.—A photograph of the spectrum of Nova Geminorum No. 2 taken on the nights of February 12 and 13 with a total exposure of nine hours shows that it has remained essentially unchanged during the past year. The spectrum is of the definite Wolf-Rayet type with bright hydrogen lines and an exceedingly prominent bright band at λ 4686. Several other Wolf-Rayet bands are present. The continuous spectrum is very strong.

Walter S. Adams.
Francis G. Pease.

Minima of Variable Stars of Short Period.

[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 May							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.8			24	0				
RT Sculptor.		31.5	—26	13	9.6—10.5	0	12.3	3	22;	11	14;	19	7;	26	23
UU Androm.		38.5	+30	24	10.7—11.9	1	11.7	2	15;	10	2;	17	12;	24	22
U Cephei	0	53.4	+81	20	7.0— 9.0	2	11.8	6	10;	13	21;	21	9;	28	20
Z Persei	2	33.7	+41	46	9.4—12	3	01.4	7	17;	13	20;	19	23;	26	2
TW Cassiop.		37.6	+65	19	8.2— 9.0	1	10.3	6	13;	13	17;	20	20;	28	0
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	5	14;	12	11;	19	8;	26	5
RZ Cassiop.		39.9	+69	13	6.9— 8.1	1	04.7	2	14;	9	18;	16	23;	24	3
TX Cassiop.		44.4	+62	22	9.4—10.1	2	22.2	9	1;	17	19;	26	14		
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	6	7;	14	6;	22	5;	30	4
RX Cassiop.	2	58.8	+67	11	8.6— 9.1	32	07.6			17	5				
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	1	10;	7	3;	18	14;	30	2
RT Persei		16.7	+46	12	9.5—11.5	0	20.4	4	10;	11	5;	18	0;	24	19
λ Tauri		55.1	+12	12	3.3— 4.2	3	22.9	1	1;	8	22;	16	20;	24	18
RW Tauri	3	57.8	+27	51	7.1—<11	2	18.5	5	1:	13	8;	21	16;	29	23
RV Persei	4	04.2	+33	59	9.5—11.0	1	23.4	5	20;	13	18;	21	15;	29	13
RW Persei		13.3	+42	04	8.8—11.0	15	04.8			10	20;	24	0		
SZ Tauri		31.4	+18	20	7.2— 7.7	3	03.6			10	3;	19	13;	29	0
RS Cephei	4	48.6	+80	06	9.5—12.0	12	10.1	6	16;	19	2;	31	13		
TT Aurigae	5	02.8	+39	27	7.8— 8.7	0	16.0	1	1;	14	9;	21	1;	27	17
RY Aurigae		11.5	+38	13	10.7—11.7	2	17.5	2	6;	7	17;	18	15;	29	13
RZ Aurigae		42.9	+31	40	10.6—13.3	3	00.3	6	19;	12	20;	24	21;	30	21
SV Tauri		45.8	+28	05	9.4—11.0	2	04.0	4	22;	13	14;	22	6;	30	22
Z Orionis		50.2	+13	40	9.7—10.7	5	04.9	7	18;	18	4;	28	13		
SV Gemin.		54.6	+24	28	9.8—<11	4	00.2	2	12;	10	3;	18	13:	26	13
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	3	15;	9	9;	20	20;	26	13
U Columbae	6	11.2	—33	03	9.2—10.0	2	19.2	3	19;	15	0;	20	15;	26	5
SX Gemin.		22.0	+20	37	10.8—11.5	1	08.8	4	17;	12	22;	21	2;	29	7
RW Monoc.		29.3	+ 8	54	9.0—10.8	1	21.7	5	14;	13	5;	20	20;	28	11
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0	1	11;	13	16;	25	21		
RU Monoc.	6	49.4	— 7	28	9.8—10.5	0	21.5	8	3;	15	7;	22	11;	29	16
R Can. Maj.	7	14.9	—16	12	5.8— 6.4	1	03.3	8	9;	17	11;	26	13		
RY Gemin.		21.7	+15	52	8.9—<10	9	07.2	7	12;	16	19;	26	2		
Y Camelop.		27.6	+76	17	9.5—12	3	07.3			12	22;	22	20		
TX Gemin.		30.3	+17	8	10.0—11.9	2	19.2	6	19;	15	5;	23	14		
RR Puppis		43.5	—41	08	9.4—10.7	6	10.3	1	17;	14	14;	21	0;	27	11
V Puppis	7	55.4	—48	58	4.1— 4.8	1	10.9	7	20;	15	3;	22	9;	29	16
X Carinae	8	29.1	—58	53	7.9— 8.7	0	13.0	5	4;	13	6;	21	9;	29	12
S Cancri	8	38.2	+19	24	8.2—10	9	11.6			10	3;	19	15;	29	2
RX Hydrae	9	00.8	— 7	52	9.1—10.5	2	6.8	8	7;	17	10;	26	13		
S Antliae		27.9	—28	11	6.7— 7.3	0	07.8	1	7;	7	18;	20	17;	27	5
S Velorum		29.4	—44	46	7.8— 9.3	5	22.4	6	8;	12	6;	24	3;	30	2
Y Leonis	9	31.1	+26	41	9.3—11.2	1	16.5	4	12;	12	22;	21	8;	29	19
RR Velorum	10	17.8	—41	36	10.0—10.9	1	20.5	8	12;	17	18;	27	1		
SS Carinae	10	54.2	—61	23	12.2—12.8	3	07.2	2	11;	9	1;	22	6;	28	21
ST Urs. Maj.	11	22.4	+45	44	6.7— 7.2	8	19.2	8	5;	17	0;	25	19		
RW Urs. Maj.		35.4	+52	34	10.3—11.4	7	07.9	4	0;	11	8;	18	16;	26	0
Z Draconis	11	39.8	+72	49	9.9—13.6	1	08.6	3	2;	10	21;	24	11;	31	6
RZ Centauri	12	55.6	−64	05	8.5— 8.9	1	21.0	5	7;	13	19;	21	7;	28	19
RS Can. Ven.	13	06.3	+36	28	7.5—12.5	4	19.2	4	8;	13	22;	23	12		
SS Centauri	13	07.2	—63	37	8.8—10.4	2	11.5	4	11;	11	22;	19	8;	26	19
δ Librae	14	55.6	— 8	07	4.8— 6.2	2	07.9	4	2;	11	2;	18	2;	25	2

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 May							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
U Coronae	15	14.1	+32	01	7.6—8.7	3	10.9	3	7;	10	5;	24	0;	30	22
TW Draconis		32.4	+64	14	7.3—8.9	2	19.4	2	3;	10	13;	18	23;	27	9
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	2	14;	10	6;	17	22;	25	13
SW Ophiuchi	16	11.1	—6	44	9.2—10.0	2	10.7	4	18;	12	2;	19	11;	26	19
SX Ophiuchi		12.6	—6	25	10.5—11.2	2	01.5	2	17;	10	23;	19	5;	27	11
R Arae		31.1	—56	48	6.8—7.9	4	10.2	6	8;	15	5;	24	1		
TT Herculis	16	49.9	+17	00	8.9—9.3	20	18.1	2	21;	12	14;	23	14		
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	1	5;	8	0;	21	15;	28	10
U Ophiuchi		11.5	+1	19	6.0—6.7	0	20.1	4	22;	13	7;	21	16;	30	1
u Herculis		13.6	+33	12	4.6—5.4	2	01.2	5	4;	11	8;	23	15;	29	19
TX Herculis		15.4	+42	00	8.3—9.0	1	00.7	2	0;	9	5;	23	15;	30	20
RV Ophiuchi		29.8	+7	19	9. —12	3	16.5	1	3;	8	12;	23	6;	30	15
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	6	10;	14	14;	22	18;	30	23
TX Scorpii		48.6	—34	13	7.5—8.2	0	22.6	5	20;	13	9;	20	22;	28	11
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	2	10;	10	3;	17	22;	25	16
Z Herculis		53.6	+15	09	7.1—7.9	3	23.8	4	0;	12	0;	20	0;	27	23
WX Sagittae		53.6	—17	24	9.2—10.8	2	03.1	2	20;	11	8;	19	21;	28	9
WY Sagittae	17	54.9	—23	1	9.5—10.6	4	16.0	9	22;	19	6;	28	15		
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	4	20;	15	4;	25	13		
RS Sagittarii		11.0	—34	08	5.9—6.3	2	10.0	3	11;	10	17;	17	23;	25	5
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	7	16;	14	13;	21	11;	28	9
RZ Scuti		21.1	—9	15	7.4—8.3	15	03.2	2	4;	17	7				
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	3	21;	12	4;	20	10;	28	16
RX Herculis		26.0	+12	32	7.0—7.6	0	21.3	3	5;	12	2;	20	23;	29	21
SX Sagittarii		39.7	—30	36	8.7—9.8	2	01.8	5	0;	13	7;	21	15;	29	22
RR Draconis		40.8	+62	34	9.3—13	2	19.9	9	0;	17	12;	26	0		
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	7	12;	14	3;	20	19;	27	10
β Lyrae		46.4	+33	15	3.4—4.1	12	21.8	2	0;	14	22;	27	20		
U Scuti	18	48.9	—12	44	9.1—9.6	0	22.9	6	23;	16	12;	26	1		
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	3	18;	11	8;	18	21;	26	11
RV Lyrae		12.5	+32	15	11. —12.8	3	14.4	7	22;	15	3;	22	8;	29	13
RS Vulpec.		13.4	+22	16	6.9—8.0	4	11.4	7	9;	16	8;	25	7		
U Sagittae		14.4	+19	26	6.5—9.0	3	09.1	3	16;	10	11;	23	23;	30	17
Z Vulpec.		17.5	+25	23	7.3—8.5	2	10.9	6	16;	14	1;	21	9;	28	18
TT Lyrae		24.3	+41	30	9.3—11.6	5	05.8	2	8;	7	14;	18	2;	28	13
UZ Draconis		26.1	+68	44	9.0—9.8	1	15.1	7	9;	13	22;	20	11;	26	23
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	4	11;	10	11;	22	12;	28	12
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	5	2;	11	18;	25	0;	31	16
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	4	22;	14	2;	23	5		
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	1	7;	9	18;	18	4;	26	14
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	2	22;	9	17;	23	7;	30	2
UW Cygni		19.6	+42	55	10.5—13	3	10.8	7	2;	14	0;	20	22;	27	19
V Vulpec.		32.3	+26	15	8.2—9.8	37	19.0								
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	6	11;	16	1;	25	16		
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	4	23;	14	4;	23	9		
Y Cygni		48.1	+34	17	7.1—7.9	1	12.0	7	14;	15	1;	22	13;	30	1
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	1	18;	13	11;	25	3;	30	23
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2			10	9;	20	11;	30	13
VV Cygni	21	02.3	+45	23	12.1—13.8	1	11.4	1	9;	8	18;	23	12;	30	21
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	2	12;	12	5;	21	22;	31	14
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	7	12;	15	8;	23	5;	31	2
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3			18	20				
RT Lacertae	21	57.4	+43	24	9.1—10.5	5	01.7	2	20;	13	0;	23	3		
RW Lacertae	22	40.6	+49	08	10.2—11.2	5	04.4	1	9;	11	18;	22	3;	27	8
X Lacertae	22	45.0	+55	54	8.2—8.6	5	10.6	4	12;	15	9;	20	20;	31	17
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.3	5	21;	14	4;	22	12;	30	19
Y Piscium		29.3	+7	22	9.0—12.0	3	18.4	3	18;	11	7;	18	19;	26	8
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	3	1;	11	7;	19	13;	27	19

Maxima of Variable Stars of Short Period.

[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. May							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SX Cassiop.	0	05.5	+54	20	8.6—9.4	36	13.7								
SY Cassiop.	0	09.8	+57	52	9.3—9.9	4	1.7	4	11;	12	14;	20	18;	28	21
RR Ceti	1	27.0	+ 0	50	8.3—9.0	0	13.3	8	3;	15	21;	23	15;	31	9
RW Cassiop.	1	30.7	+57	15	8.9—11.0	14	19.2			15	17;	30	2		
V Arietis	2	09.6	+11	46	8.3—9.0	0	23.8	4	12;	12	11;	20	9;	28	8
SU Cassiop.	2	43.0	+68	28	6.5—7.0	1	22.8	2	12;	10	7;	18	2;	25	21
TU Persei	3	01.8	+52	49	11.4—12.2	0	14.6	5	16;	12	23;	20	6;	27	13
RW Camelop.	3	46.2	+58	21	8.2—9.4	16	00.0	9			25				
SX Persei	4	10.2	+41	27	10.4—11.2	4	07.0	1	20;	10	10;	19	0;	27	14
SV Persei		42.8	+42	07	8.8—9.6	11	03.1	7	7;	18	11;	29	14		
RX Aurigae	4	54.5	+39	49	7.2—8.1	11	15.0	5	14;	17	5;	28	20		
SX Aurigae	5	04.6	+42	02	8.0—8.7	1	12.8	1	14;	9	5;	16	21;	24	13
SY Aurigae		05.5	+42	41	8.4—9.5	10	03.3	2	0;	12	3;	22	7		
Y Aurigae		21.5	+42	21	8.6—9.6	3	20.6	1	8;	9	1;	16	18;	24	11
RZ Gemin.	5	56.6	+22	15	9.1—10.0	5	12.7	4	15;	10	4;	21	5;	26	18
RS Orionis	6	16.5	+14	44	8.2—8.9	7	13.6	7	1;	14	14;	22	4;	29	17
T Monoc.		19.8	+ 7	08	5.7—6.8	27	00.3			21	18				
RZ Camelop.		23.7	+67	06	11.0—13.0	0	11.5	4	3;	11	8;	18	3;	25	18
W Gemin.		29.2	+15	24	6.7—7.5	7	22.0	8	9;	16	7;	24	5		
ζ Gemin.	6	58.2	+20	43	3.7—4.3	10	03.7	3	8;	13	12;	23	16		
RU Camelop.	7	10.9	+69	51	8.5—9.8	22	06.5			21	1				
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	2	20;	10	19;	18	17;	26	16
V Carinae	8	26.7	−59	47	7.4—8.1	6	16.7	1	10;	8	3;	14	19;	21	12
T Velorum	8	34.4	−47	01	7.6—8.5	4	15.3	4	19;	14	2;	23	8		
V Velorum	9	19.2	−55	32	7.5—8.2	4	08.9	8	7;	17	1;	25	19		
Z Leonis	9	46.4	+27	22	7.9—9.6	59	0.0					27			
RR Leonis	10	02.1	+24	29	9.1—10.1	0	10.9	2	3;	8	21;	22	11;	29	6
SU Draconis	11	32.2	+67	53	8.9—9.6	0	15.8	7	14;	14	4;	20	18;	27	9
S Muscae	12	07.4	−69	36	6.4—7.3	9	15.8	3	13;	13	5;	22	21		
SW Draconis		12.8	+70	04	8.8—9.6	0	13.7	5	15;	13	14;	21	14;	29	13
T Crucis		15.9	−61	44	6.8—7.6	6	17.6	2	8;	9	1;	22	12;	29	7
R Crucis		18.1	−61	04	6.8—7.9	5	19.8	2	5;	8	1;	19	16;	25	12
S Crucis	12	48.4	−57	53	6.5—7.6	4	16.6	3	19;	13	4;	22	13;	31	23
W Virginis	13	20.9	− 2	52	8.7—10.4	17	06.5			14	9;	31	15		
SS Hydrae		25.0	−23	08	7.4—8.1	8	4.8	2	19;	11	0;	19	5;	27	10
RV Urs. Maj.	13	29.4	+54	31	9.2—9.9	0	11.2	1	17;	8	18;	22	19;	29	19
ST Virginis	14	22.5	− 0	27	10.3—11.4	0	09.9	8	9;	16	14;	24	19		
V Centauri		25.4	−56	27	6.4—7.8	5	11.9	2	11;	13	10;	18	22;	29	22
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	6	1;	13	14;	21	3;	28	16
RU Bootis	14	41.5	+23	44	12.8—14.3	0	11.9	2	15;	10	1;	17	11;	24	21
R Triang. Austr.	15	10.8	−66	08	6.7—7.4	3	09.3	2	21;	9	15;	23	5;	29	23
S Triang. Austr.	15	52.2	−63	29	6.4—7.4	6	07.8	2	2;	8	10;	21	2;	27	9
S Normae	16	10.6	−57	39	6.6—7.6	9	18.1	4	5;	14	0;	23	18		
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	2	15;	11	2;	19	22;	28	19
RV Scorpii	16	51.8	−33	27	6.7—7.4	6	01.5	1	4;	7	6;	19	9;	31	12
X Sagittarii	17	41.3	−27	48	4.4—5.0	7	00.3	3	0;	10	0;	24	1;	31	1
Y Ophiuchi		47.3	− 6	07	6.1—6.5	17	02.9	2	22			20	1		
W Sagittarii	17	58.6	−29	35	4.3—5.1	7	14.3	1	9;	8	23;	24	3;	31	18
Y Sagittarii	18	15.5	−18	54	5.4—6.2	5	18.6	4	16;	10	11;	22	0;	27	18
U Sagittarii		26.0	−19	12	6.5—7.3	6	17.9	1	2;	7	20;	21	8;	28	2
Y Scuti	18	32.6	− 8	27	8.7—9.2	10	08.3			10	2;	20	11;	30	19
Y Lyrae		34.2	+43	52	11.3—12.3	0	12.1	6	6;	12	7;	24	9;	30	9
RZ Lyrae		39.9	+32	42	9.9—11.2	0	12.3	6	6;	12	9;	24	16;	30	19

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. May							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
RT Scuti	18	44.1	−10	30	9.1— 9.7	0	11.9	4	10;	10	9;	22	6;	28	5
κ Pavonis		46.6	—67	22	3.8— 5.2	9	02.2	9	11;	18	13;	27	15		
U Aquilae	19	24.0	− 7	15	6.2— 6.9	7	00.6	3	3;	10	3;	24	4;	31	5
XZ Cygni		30.4	+56	10	8.6— 9.3	0	11.2	3	5;	10	5;	24	5;	31	5
U Vulpec.		32.2	+20	07	6.5— 7.6	7	23.5	7	6;	15	6;	23	6;	31	5
SU Cygni		40.8	+29	01	6.2— 7.0	3	20.3	2	12;	10	4;	17	21;	25	13
η Aquilae		47.4	+ 0	45	3.7— 4.5	7	04.2	7	17;	14	22;	22	2;	29	6
S Sagittae		51.5	+16	22	5.6— 6.4	8	09.2	4	4;	12	13;	20	23;	29	8
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	6	2:	12	10;	25	1;	31	9
X Cygni	20	39.5	+35	14	6.0— 7.0	16	09.3	4	16;	21	1				
T Vulpec.		47.2	+27	52	5.5— 6.1	4	10.5	2	16;	11	13;	20	10;	29	7
WY Cygni		52.3	+30	03	9.6—10.4	0	13.5	3	3;	16	14;	23	8;	30	1
RV Capric.		55.9	−15	37	9.2—10.1	0	10.7	2	8;	9	1;	22	12;	29	5
TX Cygni	20	56.4	+42	12	8.5− 9.7	14	17.4	5	11;	20	4				
VY Cygni	21	00.4	+39	34	8.8− 9.5	7	20.6	8	4;	16	1;	23	22;	31	18
SW Aquarii		10.2	— 0	20	9.9−10.8	0	11.0	4	12;	11	10;	18	7;	25	4
VZ Cygni	21	47.7	+42	40	8.2− 9.2	4	20.7	2	18;	12	11;	22	5;	31	22
Y Lacertae	22	05.2	+50	33	9.1− 9.6	4	07.8	5	14;	14	5;	22	22;	31	13
δ Cephei		25.5	+57	54	3.7− 4.6	5	08.8	1	17;	12	11;	23	4;	28	13
Z Lacertae		36.9	+56	18	8.2− 9.0	10	21.1	4	17;	15	14;	26	12		
RR Lacertae		37.5	+55	55	8.5− 9.2	6	10.1	4	15;	11	1;	23	21;	30	7
V Lacertae	22	44.5	+55	48	8.5— 9.5	4	23.6	2	18;	12	17;	22	16;	27	16
SW Cassiop.	23	03.7	+58	11	9.2— 9.7	5	10.6	2	4;	13	1;	23	22;	29	9
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	7	1;	13	8;	19	15;	25	22
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4	1	7;	13	11;	25	14		
V Cephei	23	51.7	+82	38	6.0—7.0	0	23.6	2	11;	12	10;	22	10;	27	9

New Elements of V and X Lacertae.—In the *Monthly Notices* of the Royal Astronomical Society for January 1916, Mr. C. Martin and Professor H. C. Plummer give the results of their study of the variables in Lacerta. The elements of maximum for V Lacertae

J. D. 2416666.76 + 4.98269 E,

determined at the Laws Observatory, are changed by these observations to

J. D. 2420050.456 + 4.983352 E.

The elements of minimum for X Lacertae

J. D. 2416672.45 + 5.44269 E,

also determined at the Laws Observatory, are changed to elements of maximum

J. D. 2419750.55 + 5.444442.

This new period is slightly longer than the former period used.

In this study the star B. D. + 55°2808 was selected as a comparison star, but it itself proved to be a variable. It has a variation of about a half a magnitude and is probably irregular.

The authors of this note express the opinion that about one in five of the stars in the the neighborhood of the ninth magnitude is variable to a measurable extent.

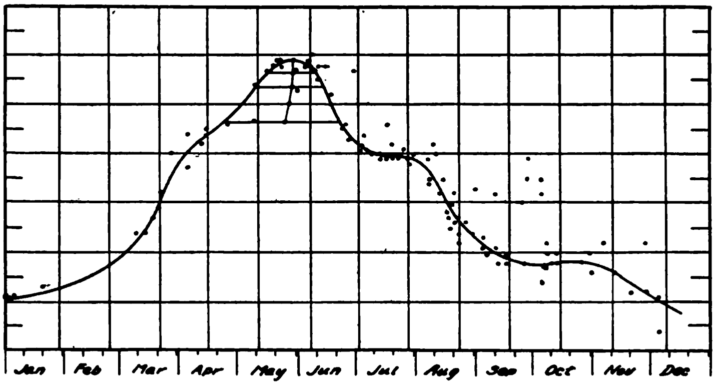
The Colors of Fifteen Variables in M 3.—We know from Bailey's work that in length of period and nature of light variation the variable stars in the globular cluster Messier 3 are closely similar to the short period Cepheids found outside the clusters. From recent measures of photographic and photovisual magnitudes it now appears that the spectra of these stars are also similar to the spectra of the non-cluster variables of analogous period. The following values, which indicate the color at or near maximum light, are given only to tenths since they are subject to some revision when the study of the cluster is completed.

No. Var.	Photovisual Magnitude	Color Index	No. Var.	Photovisual Magnitude	Color Index
22	15.2	+0.2	71	15.2	+0.1
43	15.2	+0.1	85	15.3	+0.0
44	15.3	+0.2	98	15.3	+0.2
56	15.3	−0.2	99	15.2	+0.1
61	15.1	−0.1	107	15.2	+0.3
65	14.9	+0.0	121	15.1	−0.2
70	15.2	−0.0	128	15.2	−0.1

The average photovisual magnitude at maximum is 15.20. The average color index is +0.05, corresponding to spectral type A1, which is practically identical with the average spectral type at maximum of the Cepheids with periods less than a day. If we assume that, in keeping with other Cepheids, the average absolute brightness of these variables in Messier 3 is not fainter than zero magnitude at maximum, then we derive at once that the parallax of the cluster is less than 0″.0001.

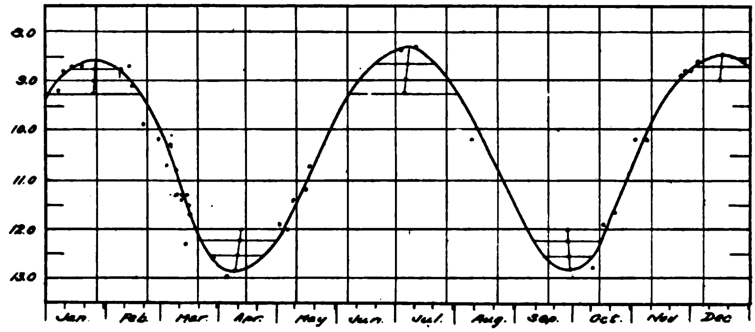
One of the brightest stars in the cluster, No. 95, is a variable of a totally different type. The range is small. Bailey was unable to determine the period and suggested that it might be an Algol variable. The new magnitude measures show the star to be very red; it may therefore be a variable of long or irregular period. Many such stars are known to be of high luminosity.

HARLOW SHAPLEY.



LIGHT CURVE of 193449 R CYGNI for 1915
Maximum May 27 (7.1)
Observations by Amer. Assn. of Variable Star Observers

Chas B. Lindsley
Cin'ti., O.



LIGHT CURVE of 060450 X AURIGAE for 1915 Chas. B. Lindsley Cinti., O.
Maximum No. 1, Jan. 26, (8.6); No. 2, Jul. 7, (8.3), No. 3, Dec. 17 (8.4)
Minimum No. 1, Apr. 9, (12.9); No. 2, Sep. 28, (12.8). Obs. by A. A. of V. S. O.

COMET AND ASTEROID NOTES.

Comet 1915 *e* (Taylor).—Early in February Professor Barnard observed that this comet had developed a double nucleus. This comet is now very faint and consequently this interesting development can be observed only by means of the largest telescopes. Professor Barnard has made measures of the components as follows:

1916 Feb.	9	14h 28m G. M. T.	P. A. 21°.3	Distance 9″.2
	26	13 44 "	" 23 .3	" 12 .1

The two parts seem to be separating slowly.

New Comet Discovered by Neujmin.—The first comet for the year 1916 was discovered by Neujmin at Simeis on February 24. It was of about the eleventh magnitude at the time of discovery and was moving south slowly. The following positions of this comet have been received to date through the Harvard College Observatory Bulletins.

G.M.T.	R.A. h m s	Dec. ° ′ ″	Observer	Place
Feb. 29.6120	8 58 46.28	+13 35 18.2	Van Biesbroeck	Yerkes Observatory
29.7355	8 58 46.62	13 31 20.0	Brown	Dearborn "
Mar. 3.4877	8 59 22.9	12 4 5	Hartwig	Bamberg
3.6745	8 59 26.84	11 58 12.9	Van Biesbroeck	Yerkes Observatory
3.6871	8 59 26.68	11 57 50.04	Fox	Dearborn "
4.5697	8 59 44.67	11 30 3.6	Van Biesbroeck	Yerkes "
4.600	8 59 43.80	11 29 28.03	Pettit	Washburn College
7.6585	9 1 3.5	9 53 20	Aitken	Lick Observatory
8.5666	9 1 32.26	9 25 8.2	Van Biesbroeck	Yerkes "

Two sets of elements have been received. The first by Castro at the Observatorio Nacional, Santiago, Chile, shows the comet to have been at perihelion on March 3; the second, by Miss Young and Messrs. Jeffers and Pierce at the University of California, shows the comet to have been at perihelion on March 11. The latter also gives 5.19 years at the period of the comet.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Feb.-Mar., 1916.

Again unusually inclement and unfavorable meteorological conditions have greatly hindered our observational work and a meagre report results. Locally there were only eight clear days in the month of February, and there seems to have been a prevalence of fog on the Pacific coast.

We welcome two new members of the Association this month, Rev. C. S. Kathan, "K" of Aitken, Minn., who observes with a four-inch refractor, and R. A. Klahr, "Kl" of Colorado Springs, Colo.

Mr. Lacchini's report for last month arrived too late for publication, and is therefore included in this month's report.

Mr. S. C. Hunter is to be congratulated on his readable article, entitled "The Interest in Astronomy", published in the March issue of "The Guide to Nature." A print of his well-equipped observatory appears with the article.

Messrs. Eaton, McAteer, and Nolte deserve great credit for the many valuable early morning observations they contribute to this report.

The following calculated dates of maxima taken from "The Companion to the Observatory" are of interest:

April 3	163266	R Draconis	April 14	205923	R Vulpeculae
5	043274	X Camelop	18	043065	T Camelop
5	142584	R Camelop	20	065355	R Lyncis
6	021024	R Arietis	25	154615	R Serpentis
11	194048	RT Cygni			

Members of the Association are urged to spread the propaganda of Variable star observing as far as possible, and endeavor to secure new members for the Association. A variety of causes has resulted in a depletion of our list of active observers, and in order that a good monthly average of observations may be maintained it is necessary to increase the number of observers. Any articles concerning variable star observing that our members can publish in the Press and other publications, will go far to advertise the practical nature of the work in which we are engaged, and attract recruits to our ranks.

The following members contributed to this report:—Messrs. Bouton, Burbeck, Eaton, Hoge, Hunter, Lacchini, Lindsley, Mach, McAteer, Mundt, Nolte, Pickering, Richter, Vrooman, Miss Swartz and Miss Young.

William Tyler Olcott,
Corresponding Sec'y.

Norwich, Conn.
Mar. 10, 1916.

Variable Star Observations Feb.-Mar., 1916.

001046
X Androm.

Mo.	Day	Est.	Obs.
2	21	11.0	V
	28	9.9	B

001755
T Cassiop.

Mo.	Day	Est.	Obs.
1	28	9.0	R
2	3	8.9	Bu
	4	9.1	Nt
	14	8.6	S
	15	8.4	B
	21	8.7	M
	28	8.6	S

001909
S Ceti

Mo.	Day	Est.	Obs.
2	3	10.4	Bu

003179
X Cephei

Mo.	Day	Est.	Obs.
2	7	11.0	Hu

004435
V Androm.

Mo.	Day	Est.	Obs.
2	4	11.5	Nt

004958
W Cassiop.

Mo.	Day	Est.	Obs.
2	28	9.7	B
	29	10.8	M

010940
U Androm.

Mo.	Day	Est.	Obs.
2	9	12.0	Hu

011208
S Piscium

Mo.	Day	Est.	Obs.
2	3	9.6	Bu

011712
U Piscium

Mo.	Day	Est.	Obs.
2	3	10.2	Bu

012502
R Piscium

Mo.	Day	Est.	Obs.
1	28	10.8	R

014958
X Cassiop.

Mo.	Day	Est.	Obs.
2	7	11.1	Y
	28	10.3	B
	29	10.6	M

015254
U Persei

Mo.	Day	Est.	Obs.
1	28	8.5	R
2	3	7.8	Bu
	7	8.0	Hu
	21	8.4	V
	29	8.2	M

015912
S Arietis

Mo.	Day	Est.	Obs.
2	22	12.9	B

021024
R Arietis

Mo.	Day	Est.	Obs.
2	3	10.2	Bu
	14	9.3	R
	14	9.5	S
	28	8.4	S

021403
o Ceti

Mo.	Day	Est.	Obs.
12	21	2.8	L
1	10	3.1	L
	14	3.4	L
	16	3.4	L
	24	3.5	L
	28.6	3.9	R
	29.6	3.9	R
	30	3.6	L
	30.6	4.0	R
	31	4.1	E
	31.6	4.0	R
	31	4.1	Mu
2	1	4.1	E
	1	4.1	Ma
	2	4.1	E
	3	4.2	E
	3	4.2	Bu
	3	4.4	Pi
	3.5	4.4	Nt
	5	4.2	Ly
	5.6	4.2	R
	6.6	4.4	R
	7	4.2	E
	7	3.9	Ma
	7.5	4.5	Nt
	9.5	4.3	Ly
	10.5	4.6	Nt
	11	4.1	L
	13	4.5	E
	13	4.4	L
	14.5	4.6	Nt
	14.6	4.6	R
	14	4.4	L
	21.5	4.8	Nt
	21.6	4.9	R
	26.6	5.2	Nt
	29.5	5.2	Nt

021658
S Persei

Mo.	Day	Est.	Obs.
1	28	9.6	R
2	3	8.8	Bu

022000
R Ceti

Mo.	Day	Est.	Obs.
1	28	8.7	R
2	3	8.6	Bu

023133
R Triang.

Mo.	Day	Est.	Obs.
1	29	6.8	R
2	3	7.2	Bu
	9	6.7	Hu

024356
W Persei

Mo.	Day	Est.	Obs.
1	29	10.8	R
2	3	10.2	Bu
	9	10.0	Hu
	29	10.0	M

030514
U Arietis

Mo.	Day	Est.	Obs.
2	7	11.0	Y

032043
Y Persei

Mo.	Day	Est.	Obs.
1	29	10.0	R
2	3	9.6	Bu
	9	10.0	Hu
	29	10.0	M

033362
U Camelop.

Mo.	Day	Est.	Obs.
1	29	8.7	R

035124
T Eridani

Mo.	Day	Est.	Obs.
1	31	7.5	Ho

035915
V Eridani

Mo.	Day	Est.	Obs.
1	30	9.0	R
	31	9.0	Pi
	31	9.0	Ho

042215
W Tauri

Mo.	Day	Est.	Obs.
1	30	8.7	R
	31	10.1	Pi
2	3	9.5	Bu
	4	9.7	Nt
	5	9.6	Ly
	9	9.4	Hu
	21	9.2	M
	29	10.0	Pi

043065
T Camelop.

Mo.	Day	Est.	Obs.
2	3	9.6	Bu

043208
RX Tauri

Mo.	Day	Est.	Obs.
1	30	11.1	R
2	3	10.6	Pi
	3	10.4	E
	7	10.6	Y
	9	10.3	Hu
	29	11.4	B

043274
X Camelop.

Mo.	Day	Est.	Obs.
2	14	10.3	L

044617
V Tauri

Mo.	Day	Est.	Obs.
1	30	10.8	R
2	4	11.7	Nt
	7	12.4	Y

045307
R Orionis

Mo.	Day	Est.	Obs.
2	7	11.6	Y
	10	11.0	B

045514
R Leporis

Mo.	Day	Est.	Obs.
1	10	8.9	L
	16	8.2	L
	30	8.7	R
	31	8.8	Ho
2	3	8.1	Bu
	3	9.0	Pi
	13	8.5	L
	14	9.3	L
	29	9.3	M

050022
T Leporis

Mo.	Day	Est.	Obs.
1	30	9.2	R
	31	9.0	Ho
2	3	9.5	Bu
	3	9.5	Pi

050003
V Orionis

Mo.	Day	Est.	Obs.
2	3	9.8	Bu
	3	9.5	B
	4	9.9	B
	29	11.4	B
	29	11.2	Pi

052034
S Aurigae

Mo.	Day	Est.	Obs.
2	3	9.2	Bu
	6	9.8	L

052404
S Orionis

Mo.	Day	Est.	Obs.
1	31	10.0	Ho
2	3	10.2	Bu
	10	9.5	B

053005
T Orionis

Mo.	Day	Est.	Obs.
1	10	9.2	L
	31	9.6	Ho
2	3	10.2	Bu
	3	9.5	Pi
	3	9.6	Nt
	5	10.3	Ly
	10	9.5	B
	19	9.2	Ho
	28	9.6	Pi

054319
SU Tauri

Mo.	Day	Est.	Obs.
2	3	9.6	Bu
	3	9.5	V
	3.5	9.7	E
	4.5	9.5	B
	7	9.7	Y
	7.5	9.5	E

SU Tauri

Mo.	Day	Est.	Obs.
2	10.5	9.6	B
	21	9.4	V
	22.5	9.6	B
	23.7	9.6	E
	27	9.4	V

054920
U Orionis

Mo.	Day	Est.	Obs.
1	10	11.6	L
	31	10.8	E
2	7	11.2	Pi
	7	10.8	Y
	21	10.5	M
	25	10.9	Hu

054974
V Camelop.

Mo.	Day	Est.	Obs.
1	31	10.2	E
2	1	9.7	E
	2	9.9	E
	3	10.0	Bu
	3	9.8	V
	3	10.0	E
	7	10.4	E
	21	11.0	V
	23	11.0	E
	27	11.0	V

060124
S Leporis

Mo.	Day	Est.	Obs.
1	30	6.2	R
	31	6.5	Ho

060450
X Aurigae

Mo.	Day	Est.	Obs.
1	10	10.0	L
	26	10.3	L
2	6	11.7	L
	28	13.6	B

060547
SS Aurigae

Mo.	Day	Est.	Obs.
1	30.3	10.5	L
	31.6	10.3	R
	31.7	10.4	E
2	1.5	10.5	B
	1.6	10.6	E
	2.5	10.5	E
	3.5	10.6	Pi
	3.5	10.5	M
	3.5	10.7	E
	3	10.7	V
	3	10.4	Bu
	4.5	11.1	B
	5.2	10.6	L
	5.6	11.0	R
	6.2	10.6	L

VARIABLE STAR OBSERVATIONS Feb.-Mar., 1916—Continued.

SS Aurigae

Mo.	Day	Est.	Obs.
2	6.6	11.2	R
	7.3	11.1	L
	7.5	11.1	E
	9.7	12.6	E
	10.5	12.8	B

061647
V Aurigae

Mo.	Day	Est.	Obs.
2	3	9.6	Bu

061702
V Monoc.

Mo.	Day	Est.	Obs.
1	31	7.7	Ho
2	3	7.8	Bu
	4	7.9	Pi
	21	8.8	M
	29	9.0	Pi

065111
Y Monoc.

Mo.	Day	Est.	Obs.
2	1	11.7	E

065208
X Monoc.

Mo.	Day	Est.	Obs.
1	10	8.6	L
	31	9.7	R
	31	8.6	Ho
2	3	8.3	M
	3	8.7	Bu
	4	8.8	Pi
	7	8.5	Pi
	29	7.4	Pi

065355
R Lyncis

Mo.	Day	Est.	Obs.
1	31	9.1	R
2	3	9.4	Bu

070122a
R Gemin.

Mo.	Day	Est.	Obs.
1	31	11.2	R
2	3	10.2	Pi
	3	10.3	Nt
	21	11.3	M

070122
TW Gemin.

Mo.	Day	Est.	Obs.
1	31	8.6	R
2	3	8.4	Pi
	3	8.4	Nt
	21	8.8	M

070122b
Z Gemin.

Mo.	Day	Est.	Obs.
2	3	12.3	Nt

070310
R Can. Min.

Mo.	Day	Est.	Obs.
1	10	10.8	L
2	7	10.6	Pi
	14	9.9	B
	29	10.4	Pi

072708
S Can. Min.

Mo.	Day	Est.	Obs.
1	10	7.8	L
	16	8.1	L
	31	7.6	Mu
	31	8.3	R
2	1	8.5	E
	3	8.4	Bu
	3	8.4	Pi
	7	8.8	Ly
	7	8.6	Pi
	13	8.8	L
	14	8.8	S
	21	9.0	M
	28	9.4	Pi

072811
T Can. Min.

Mo.	Day	Est.	Obs.
2	1	12.3	E
	22	13.7	B

073508
U Can. Min.

Mo.	Day	Est.	Obs.
1	10	9.3	L
	30	8.7	L
2	3	8.2	Bu
	7	8.3	Pi
	13	8.9	L
	14	8.5	B
	21	8.8	M

073723
S Gemin.

Mo.	Day	Est.	Obs.
2	28	13.8	B

074323
T Gemin.

Mo.	Day	Est.	Obs.
2	1	12.5	E

074922
U Gemin.

Mo.	Day	Est.	Obs.
2	4.5	13.9	B

081112
R Cancri

Mo.	Day	Est.	Obs.
1	10	10.2	L
2	5	9.8	R
	10	9.1	B
	11	9.3	L
	15	9.0	Bu
	23	9.1	E
	29	9.2	Pi

081617
V Cancri

Mo.	Day	Est.	Obs.
1	31	8.4	E
2	5	8.3	R
	29	8.2	Pi

082405
RT Hydrae

Mo.	Day	Est.	Obs.
1	10	8.4	L

083019
U Cancri

Mo.	Day	Est.	Obs.
2	2	12.7	E

084803
S Hydrae

Mo.	Day	Est.	Obs.
1	31	9.6	E
2	7	9.6	Pi
	14	10.1	R
	15	8.9	Bu
	28	11.2	Pi

085008
T Hydrae

Mo.	Day	Est.	Obs.
2	15	9.4	Bu
	23	9.7	E

085120
T Cancri

Mo.	Day	Est.	Obs.
1	14	9.5	L

090151
V Urs. Maj.

Mo.	Day	Est.	Obs.
1	16	10.2	L
	28	10.2	R
	28	10.0	R
	30	10.0	R
	31	10.8	R
	31	10.4	Pi
2	3	10.2	M
	5	10.0	R
	6	10.3	R
	10	10.5	B
	21	10.3	V
	21	10.4	R
	22	10.7	Mu

093014
X Hydrae

Mo.	Day	Est.	Obs.
1	31	9.7	E
2	15	9.2	Bu
	29	8.6	Pi

093934
R Leo. Min.

Mo.	Day	Est.	Obs.
1	31	7.4	E
2	3	7.5	M
	3	7.1	Pi
	14	7.5	S
	15	7.0	Bu
	28	8.1	S
	29	7.7	Hu

094211
R Leonis

Mo.	Day	Est.	Obs.
1	10	6.4	L
	16	6.9	L
2	7	8.2	Pi
	7	7.7	Ly
	11	8.2	L
	13	7.7	M
	14	8.2	S
	14	8.4	R
	15	7.9	B
	22	8.7	Mu

094622
Y Hydrae

Mo.	Day	Est.	Obs.
2	15	7.0	Bu
	29	6.8	Pi

095421
V Leonis

Mo.	Day	Est.	Obs.
2	22	12.8	Y
	29	13.2	B

103212
U Hydrae

Mo.	Day	Est.	Obs.
1	10	5.1	L

103769
R Urs. Maj.

Mo.	Day	Est.	Obs.
1	31	8.3	Pi
2	3	8.5	M
	13	8.9	M
	14	8.9	S
	14	9.1	R
	15	8.6	B
	21	9.5	Bu
	21	9.6	M
	28	9.7	S
	28	9.7	Pi
	29	10.0	M

104620
V Hydrae

Mo.	Day	Est.	Obs.
1	10	6.3	L
2	21	7.4	Bu
	29	7.0	Pi

104814
W Leonis

Mo.	Day	Est.	Obs.
2	22	12.5	Y
	29	12.8	B

121418
R Corvi

Mo.	Day	Est.	Obs.
2	1	10.0	Ho
	13	9.3	M

122532
T Can. Ven.

Mo.	Day	Est.	Obs.
2	29	10.6	Pi

122803
Y Virginis

Mo.	Day	Est.	Obs.
2	1	9.0	Ho
	13	9.6	M

123160
T Urs. Maj.

Mo.	Day	Est.	Obs.
2	28	12.7	B

123307
R Virginis

Mo.	Day	Est.	Obs.
1	14	6.3	L
2	12	7.6	L
	13	8.0	M

123459
RS Urs. Maj.

Mo.	Day	Est.	Obs.
1	31	10.9	Pi
2	7	11.0	Pi
	13	11.2	M

123961
S Urs. Maj.

Mo.	Day	Est.	Obs.
1	16	7.9	L
	31	8.3	Pi
2	1	8.0	E
	3	8.3	M
	4	7.9	Pi
	12	8.0	L
	13	8.0	M
	14	7.7	R
	15	8.0	B
	21	7.8	Bu
	28	8.5	S

132422
R Hydrae

Mo.	Day	Est.	Obs.
1	10	9.2	L
2	12	8.1	L

132706
S Virginis

Mo.	Day	Est.	Obs.
1	10	7.7	L
	16	7.6	L
2	1	7.8	Ho
	12	8.0	L
	13	8.4	M

134440
R Can. Ven.

Mo.	Day	Est.	Obs.
1	10	7.5	L
	31	8.2	E
2	13	8.3	M
	21	7.3	Bu
	28	8.4	Pi

141567
U Urs. Min.

Mo.	Day	Est.	Obs.
2	14	8.7	S
	21	8.8	Bu
	28	8.8	S
	28	9.0	Pi
	29	9.0	B

141954
S Bootis

Mo.	Day	Est.	Obs.
1	31	12.8	E

142539
V Bootis

Mo.	Day	Est.	Obs.
1	10	9.4	L
2	13	9.3	M
	29	9.9	Pi

142584
R Camelop.

Mo.	Day	Est.	Obs.
2	29	10.6	B

VARIABLE STAR OBSERVATIONS Feb.-Mar., 1916—Continued.

Star		Mo.	Day	Est.	Obs.
143227	R Bootis	1	10	9.2	L
			16	9.3	L
150018	RT Librae	2	1	9.6	Ho
150519	T Librae	2	1	10.8	Ho
150605	Y Librae	1	14	9.3	L
		2	12	8.8	L
151520	S Librae	1	14	8.5	L
		2	12	8.7	L
153378	S Urs. Min.	1	14	10.8	L
		2	4	9.9	B
			7	9.6	Ly
			14	10.4	L
			21	9.6	Bu
			21	10.4	R
			28	10.2	Pi
154428	R Cor. Bor.	1	10	6.4	L
			14	6.7	L
		2	7.9	6.2	Nt
			12.7	6.3	L
			13.9	6.0	M
			14.7	6.3	L
			15.9	6.2	Nt
	R Cor. Bor.	2	26.6	6.0	Nt
			28.7	6.1	Nt
			29.6	6.1	Nt
			29.9	5.9	M
155847	X Herculis	2	7	6.1	Nt
			15	6.5	Nt
			28	7.1	Nt
162112	V Ophiuchi	2	1	7.8	Ho
162119	U Herculis	2	29	11.2	M
162807	SS Herculis	1	10	11.5	L
		2	12	10.9	L
163172	R Urs. Min.	2	13	10.4	M
			21	9.9	R
			23	10.5	E
			29	9.6	B
163266	R Draconis	2	13	9.7	M
164319	RR Ophiuchi	2	1	8.6	Ho
165631	RV Herculis	2	29	11.3	M
184205	R Scuti	2	7.9	5.8	Nt
			12.7	6.3	L
			14.7	6.1	L
193732	TT Cygni	1	14	8.2	L
			24	8.0	L
194632	χ Cygni	1	14	5.1	L
			24	5.5	L
200647	SV Cygni	1	14	9.3	L
		2	3	9.4	M
200938	RS Cygni	1	14	8.0	L
			24	8.2	L
201647	U Cygni	1	14	7.3	L
			30	7.6	R
		2	3	7.2	M
202946	SZ Cygni	1	14	10.0	L
			24	9.3	L
			27	10.5	R
			30	9.9	L
		2	7	9.3	L
			14	10.0	L
203847	V Cygni	2	3	10.3	M
210868	T Cephei	1	10	6.5	L
			28	8.0	R
			30	6.9	L
		2	7	7.8	Nt
			14	8.1	L
			26	7.7	Nt
213244	W Cygni	1	14	5.8	L
			16	5.8	L
			24	5.6	L
			26	5.8	L
			28	6.3	R
		2	6	5.7	L
			13	5.8	L
			14	5.7	L
213753	RU Cygni	2	3	8.9	M
213843	SS Cygni	1	14.2	11.8	L
			16.3	11.8	L
			24.2	11.8	L
			26.2	11.8	L
			30.2	11.8	L
		2	1.5	9.0	B
			3.3	9.3	V
			3.5	9.5	M
			3.5	9.6	B
			3.5	9.5	Nt
			4.5	9.9	B
			4.5	9.5	Nt
			5.2	10.0	L
			6.3	11.0	L
			7.3	11.1	L
			7.5	10.6	Ly
			7.5	11.0	Nt
	SS Cygni		10.5	11.5	B
			10.5	11.7	Nt
			11.3	11.2	L
			12.8	11.3	L
			14.7	11.5	L
			21.5	11.7	B
			29.5	11.8	B
213937	RV Cygni	1	14	7.0	L
			24	7.9	L
222439	S Lacertae	2	7	12.7	Y
223841	R Lacertae	2	7	12.1	Y
230110	R Pegasi	1	28	8.7	R
		2	7	8.4	Nt
230759	V Cassiop.	2	7	12.1	Y
233335	ST Androm.	2	3	10.3	B
			28	9.6	S
235350	R Cassiop.	1	28	9.2	R

No. of observations 431; No. of stars observed 121; No. of observers 16.

COMMUNICATIONS.

Trails of Venus and Jupiter.—The accompanying photograph of Venus and Jupiter was made with a rapid rectilinear lens of 6½ inch focus with a clear opening of 13/16 inches, just the ordinary lens that is furnished with a good hand camera. The exposure was from 6:31 to 6:36 P. M., E. S. T., February 14, 1916. The sun had set nearly an hour previously, but a little of the sunset glow is still visible. The moon was eleven days old and its light can be seen reflected from the roof of the house on the left. The position of the camera was in longitude 75° 23′ 7″.8, and latitude N 40° 3′ 3″.4. This location had been carefully calculated as an exercise from observations of the occultation of Aldebaran, December 12, 1904.

The difference in Right Ascension of the two planets was $0^h\ 3^m\ 2^s.67$ sec., and in declination, 0° 5′ 49″, making the actual angular distance between them 0° 46′ 2″, or approximately 1½ times the diameter of the full moon. As the length of the exposure was exactly five minutes the trails are 1¼° long; the change in position of the planets due to their orbital motion being too small to take into consideration. For Venus this change for the given five minutes was less than 10″ (9.962″) in Right Ascension, and for Jupiter about 1/60 as much (0.166″).

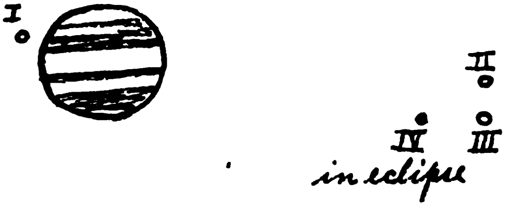
24 hours earlier the planets were within 25′ of each other, but while they were visible the atmosphere was too hazy to attempt a photograph. Although the planets look so close together it is interesting to remember that the distance between them is several times greater than from us to Venus, Jupiter being several hundred million miles beyond the brighter but smaller planet.

Henry G. Blatchley.

401 Chestnut Lane, Wayne, Pa.

Peculiar Disappearance of Jupiter's Satellite, III.—Some time since I saw a rather curious and rare occurrence, which, while it may have little or no significance, I think is worth giving an account of.

On December 1, 1915, at 8 hrs. 37 min. C. S. T., the aspect of Jupiter and his satellites was about as on the inclosed sketch. The distance from III to Jupiter was estimated by eye to be about 3½ diameters of the planet, which would make it about 140″, and from II to III was about 15″ to 20″.



Within a very few seconds of 8 hrs. 37 min. 15 sec. C. S. T., as the satellites were being watched with 300 power on our five-inch refractor, with Jupiter himself in the field, III entirely or almost entirely winked out. II and Jupiter were not affected. The disappearance and reappearance seemed gradual, and extended over a space of at least half a second: more probably 3/5 or 3/4 second—much longer than it takes to wink the eye. The seeing was very good—9 on my scale.

The question as to whether the disappearance and reappearance were actually gradual is very important. I have since experimented with the occultation of an artificial star, and I found that the disappearance had a tendency to seem gradual; and it was the disappearance which most certainly seemed gradual in the phenomenon observed; yet I know that the instant the thing happened, the apparent leisureliness of it was the most striking feature—the air of deliberation and matter-of-fact-ness. I can still, twenty days after, picture the occurrence to my mind.

When one comes to inquire into the cause, a bird at once suggests itself. But with a bird, the occultation would have lasted only so long as it would have taken him to traverse a cylinder five inches in diameter, and at the speed that birds fly, the time would hardly have been long enough to make itself felt over persistence of vision, unless indeed the bird happened to be flying right along the line of sight, or nearly so, which is improbable. More than that, I do not know whether birds are accustomed to flying at that time of night and year, that is, except owls. But this bird must have been at a considerable distance from the telescope in order to avoid occulting II, for an angle of 20″ makes an arc of less than 1.2 inches, even at 1000 ft. distance, and I believe the owl flies low.

But if one, to avoid the improbabilities noted above, turns to occultation by some kind of a body in interplanetary space, the question arises, how could a body large enough to make an occultation lasting as long as that seen, escape being itself seen? For anything that intercepts light usually reflects light.

Altogether the incident seems very curious, and it would be interesting to know whether any others have seen anything similar. I have heard mention of mysterious occultations of stars, but I have never seen an account of one, and I think they are usually ascribed to birds.

The above account is written from full notes made within a few minutes of the occultation, while the facts were still very vivid in my mind.

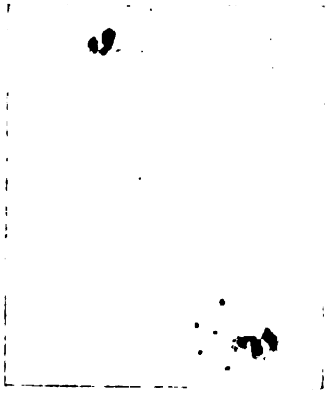
O. H. TRUMAN.

Iowa City, Iowa.

The Aurora Borealis of March 8, 1916.—A very interesting aurora borealis display was observed in Ann Arbor throughout the night of March 8. The sky was completely overcast until about 9 p. m. when it suddenly cleared. With the disappearing clouds the aurora showed itself in the form of a big arc, the summit of which was situated a little west of the due north. The lower edge of the arc was exceedingly well defined, and the part of the sky directly below it was darker than elsewhere. Several stars were visible in the dark segment, Vega being almost on the edge of the bright arc, which was rather intense and of a silvery or greenish white color. This last one extended with a decreasing brightness toward the top. Many rays were shooting from it, increasing considerably in length. Large fluctuations of light were noticed at various intervals, and toward the west, big nebulosities somewhat similar to cumulus clouds, were constantly changing in brightness. Many isolated bright patches appeared, very often near the zenith, lasting only a short time.

This auroral display put in its appearance at a time when activity on the sun's surface was very pronounced.

It was rather more intense than the aurora borealis which I observed in England last November and which happened at the time of the appearance on the sun of a group of three small spots, which became a very important group after a few days.



SUNSPOTS, MARCH 9, 1916.

The present aurora was probably related to the activity of two big spots of about equal size, one in the northern hemisphere and the other in the southern. A reproduction of these spots on a small scale is seen in the accompanying drawing, which I made at the Detroit Observatory.

Auroral displays have been frequent this winter. I have noticed sometimes in England, that although the sky was cloudy, they rendered moonless nights very bright. This, without doubt, comes about owing to the great solar activity corresponding to the maximum of sunspots.

F. HENROTEAU, D. es. Sc.

Detroit Observatory.
Ann Arbor, Mich. Mar. 9. 1916.

GENERAL NOTES.

Rev. Joel Metcalf gave an illustrated lecture to the Field and Forest Club of Boston, at the Public Library on the evening of March 9. His subject was "The Growth of Worlds."

Dr. W. S. Eichelberger gave an address, as the retiring president of the Philosophical Society of Washington, on March 4 on "The Distances of the Heavenly Bodies."

Dr. J. L. E. Dreyer has been awarded the Gold Medal of the Royal Astronomical Society (England) for his contributions to astronomical history and his catalogues of nebulae.

Sir F. W. Dyson, the English astronomer, and Dr. C. S. Sherrington, professor of physiology at Oxford, have been elected corresponding members of the Petrograd Imperial Academy of Sciences. (*Science*, Mar. 3. 1916).

Mr. Thadée Banachiewicz has recently left the Engelhardt Observatory, having been appointed an assistant at the Observatory at Dorpat and private lecturer in the University of Tourieff.

Mr. Dorsey Ash, Berkeley. Cal., is the name of the person given the number "27" in the key to plate XXV published in the November, 1915, issue of POPULAR ASTRONOMY. This face was unidentified at the time of the printing of this group. Mr. D. S. Richardson, Secretary of the Astronomical Society of the Pacific, has kindly sent us the information.

The Van Vleck Observatory of the Wesleyan University, Middletown Conn., is now practically completed. The Director, Professor Frederick Slocum, has promised us a photograph of the Observatory and a descriptive article of it for publication in POPULAR ASTRONOMY soon.

Two Spectroscopic Binaries.

	Mag.	Spectrum	R.A. (1915)	Dec. (1915)	Range in Velocity, km
			h m	° ′	
Boss 4138	5.7	F8	16 11.5	+34 5	Composite
5996	5.9	A2	23 14.1	+41 19	—86 to +10

The first of these stars is the brighter component of the well-known double star Coronae. On two of the spectrograms the spectra of both components appear and are very similar in character. A relative displacement between the components of nearly 140 km is indicated by the second of these photographs.

WALTER S. ADAMS.

An Interesting Case of two Stars of Common Motion.—In a previous number of the Journal of the A. S. P. reference was made to the extraordinary radial velocity of the large proper motion star A.Oe. 14320. A second star with the same proper motion is distant from it 5′ in declination. Two observations of the spectrum of this second star have now been obtained. The results are as follows:

	Mag.	Spectrum	R.A. (1915)	Dec. (1915)	μ	v, km
			h m	° ′	″	
A. Oe. 14320	9.2	G4	15 5.5	—15 57.5	3.76	+295
A. Oe. 14318	9.6	G5	15 5.5	—16 2.5	3.76	+307

The photographs were taken with low dispersion and the accuracy of the determinations is relatively low. The radial velocities of the two stars may, therefore, be considered as equal. The absolute parallax of the stars is +0″.035 according to a determination by Russell. Hence their distance from one another is about 8600 times the diameter of the earth's orbit, or about one thirtieth of the distance of α Centauri. We have, therefore, the interesting result that two stars separated from each other by an interval of the order of stellar distances are moving in precisely the same direction at a rate of about 580 km per second.

WALTER S. ADAMS.

The Magnesium Line λ 4571 in the Electric Furnace.—In some experiments made in 1904 with a furnace consisting of a carbon tube tested by an arc playing on the outside, I observed a very high relative intensity of the Mg line λ 4571.275, one of the weaker arc lines, when magnesium was vaporized inside the tube. A recent study of the magnesium spectrum in the tube resistance furnace at different temperatures has confirmed this observation and shows a striking contrast between this line and neighboring lines of magnesium. At 1950° C, λ 4571 is of nearly the same intensity as λ 5184, the strongest member of the *b* group, while the strong arc lines λλ 4352 and 4703 have not appeared. At temperatures above 2200°, while the arc lines are gradually developing, λ 4571 is liable to appear in absorption, its tendency to reverse being comparable with that of the calcium line λ 4227. λ 4571 remains narrow, however, and when in absorption does not show distinct emission wings in the photographs thus far made, indicating that the line may not be given by the hot vapor in the middle of the tube. At any rate, a decided strength for λ 4571 seems a clear indication of a low temperature condition.

ARTHUR S. KING.

The Chabot Observatory Dome as Wireless Aerial.—The following note, taken from the Oakland (Cal.) *Tribune* for February 19, 1916, describes a novel method of receiving wireless signals at the new Chabot Observatory.

"Wireless flashes caught by the steel dome of the Chabot Observatory in the Oakland hills bring Oakland the correct time daily, as the result of one of the most remarkable tricks in wireless telegraphy ever attempted on the Pacific coast. Having no funds to erect wireless apparatus for catching the time signals from Mare Island, Charles Burckhalter, director of the observatory, and City Electrician James Tudhope have fastened their apparatus to the steel shutters of the dome, which picks up the aerial messages, transmitting to the delicate machinery of the time-dividers the ticks of the Mare Island instrument, actuated from the government observatory.

"The wireless time will be used in the work of obtaining the exact latitude and longitude of the new observatory, which must be determined to a hair to reach correct results on delicate observations. The location of the old observatory was established in 1888 by Professor Davidson and Myron Sinclair. Experts from the coast survey will establish the latitude and longitude of the new observatory next year.

"Needing a wireless apparatus to receive the Mare Island time, Burckhalter consulted with Tudhope, planning to erect aerials. Noticing that the big dome was insulated, Tudhope conceived the idea of using it as its own antenna, and the experiment proved a perfect success. The wires are fastened to the moving machinery of the dome and grounded by a gas pipe."

Popular Astronomical Errors.—One hardly knows whether to be more impressed by the humorous or the pathetic, and so whether to laugh or cry, over popular mistakes made by many who venture into the field of Astronomy. There is the artist, for example, and sometimes a famous one, who paints a wonderful sunset scene, with the narrow crescent of the new moon dropping in the west, its horns turned the wrong way, toward the setting sun instead of away from it. Not a few artists seem to think that the position of the crescent is a matter of indifference. There is also the artist who shows the full moon high in the sky, when it must be near midnight, possibly even past that hour, and yet various activities of men going on, mothers out with their children, etc.

Whenever any unusual celestial phenomenon occurs interesting the popular mind, the journalist finds it necessary to explain and offer comments, and the result is sometimes very ridiculous. The February eclipse of the sun brought out some such matter, it being gravely announced that, in certain regions, at the maximum, the sun would be one third covered by the moon. Evidently what was meant was that the moon would cover one third of the sun's diameter; but, this being done, the moon's curved outline would leave much more than two thirds of the sun's surface exposed. One has only to draw a rough picture to see this at a glance, as Professor Rigge's pictures do in the January Popular Astronomy, dealing with that eclipse.

One newspaper, which fell under the writer's observation, in describing the February solar eclipse, told at what time observers might see "the shadow" coming across the face of the sun. I should like to ask the editor what his idea of a solar eclipse is, and what body it is that casts its shadow on the sun's face, in his opinion. He would probably answer that it is the moon's shadow. Then I should like to remind him that it is a light that casts a shadow, and to ask what light casts the shadow of the moon upon the sun's face when the latter is eclipsed. I imagine that he would hesitate before venturing on an answer, although doubtless some would even commit the blunder of saying that it is the sun's light; and thus they would make a light cast a shadow of a body back upon itself. It is easy to believe that many otherwise intelligent people, when they view an eclipse of the sun, do not realize that they are looking not at a shadow, but at the solid body of the moon, passing between the sun and the earth.

In speaking of the same eclipse, a certain paper remarked that eclipses of the moon are also of interest, particularly when seen at night. While it is true that we often see the moon in the sky by daylight, the editor needs to be instructed that no lunar eclipse was ever seen, except at night. When sun and moon are both in the sky, how is the sun to cast the earth's shadow upon the moon? The latter is never eclipsed except when at full; and full moon is never seen in the sky at the same time with the sun, for it is necessarily opposite the sun. When the full moon rises, and so comes into view, the sun sets, and so disappears; then night comes on: and only at night can the moon be seen eclipsed.

At the close of a lecture, when I had invited the audience to ask questions, one of my listeners came to me to inquire whether the moon were not "just a light in the sky." The meaning of the question seemed to be that the moon is not a material body, but a mere light. How the questioner would account for a light without a body as the basis of the light, is a mystery. Light alone, while real, is invisible. We cannot see the light traveling between sun or moon and earth. The illuminated sun or moon can be seen, because illuminated; but if either of them were removed, its light would go with it. This is proved by every sunset and every moonset.

Frederick Campbell.

Beaver Falls, N. Y.

Actual Time of Signals from the U.S. Naval Observatory, February, 1916.

Day	Time of signals Noon			Error	Time of signals 10:00 p.m.			Error	
	h	m	s		h	m	s		
1	12	0	0.01	+.01	10	0	0.00	.00	
2	12	0	0.02	+.02	10	0	0.02	+.02	
3	12	0	0.03	+.03	10	0	0.03	+.03	
4	12	0	0.02	+.02	10	0	0.03	+.03	
5	12	0	0.08	+.08	10	0	0.09	+.09	
6	12	0	0.12	+.12	10	0	0.15	+.15	Sunday
7	12	0	0.17	+.17	10	0	0.19	+.19	
8	12	0	0.20	+.20	10	0	0.08	+.08	
9	12	0	0.07	+.07	10	0	0.09	+.09	
10	11	59	59.99	—.01	9	59	59.99	—.01	
11	11	59	59.99	—.01	9	59	59.97	—.03	
12	11	50	59.99	—.01	9	59	59.98	—.02	
13	11	59	59.99	—.01	9	59	59.99	—.01	Sunday
14	11	59	59.98	—.02	9	59	59.98	—.02	
15	12	0	0.01	+.01	10	0	0.01	+.01	
16	12	0	0.02	+.02	10	0	0.02	+.02	
17	12	0	0.04	+.04	10	0	0.04	+.04	
18	12	0	0.05	+.05	10	0	0.04	+.04	
19	12	0	0.07	+.07	10	0	0.07	+.07	
20	12	0	0.07	+.07	10	0	0.08	+.08	Sunday
21	12	0	0.09	+.09	10	0	0.11	+.11	
22	12	0	0.02	+.02	10	0	0.03	+.03	
23	12	0	0.01	+.01	10	0	0.01	+.01	
24	12	0	0.02	+.02	10	9	0.02	+.02	
25	12	0	0.04	+.04	10	0	0.02	+.02	
26	11	0	0.05	+.05	10	0	0.04	+.04	
27	11	59	59.98	—.02	9	59	59.99	—.01	Sunday
28	11	59	59.99	—.01	10	0	0.01	+.01	
29	12	0	0.03	+.03	10	9	0.04	+.04	

Maximum error: Feb. 8, +0.20 sec.

Constant to be added to above errors to give error of radio signals from
Arlington +0.02 sec.
Key West +0.27

J. A. Hoogewerff,
Captain U.S. Navy
Superintendent.

U. S. Naval Observatory,
Washington, D. C.
Mar. 3, 1916.

The Production of Certain Banded Spectra in the Electric Furnace.—Experiments have recently been made with the electric furnace to obtain evidence on the origin and observe the behaviour at various temperatures of the banded spectra which have been ascribed by Fowler and others to titanium oxide, magnesium hydride and calcium hydride, respectively. All of these bands occur in sun-spot spectra, and the probability that the first named, the "Antarian bands," are due to titanium oxide has been taken as indicating the presence of oxygen in the Antarian stars as well as in the sun.

It was noted in a previous investigation that these Antarian bands do not appear when titanium is vaporized in the furnace in vacuum. The present work was undertaken to see if the presence of oxygen would bring out the bands in the furnace as it does in the arc. Tests with air in the furnace chamber at one-half atmosphere and the atmospheric pressure did not give the bands. It seemed, however, that this might indicate simply a lack of oxygen in the furnace tube due to its carbon immediately using up the oxygen of the contained air, there being little circulation through the horizontal tube. The windows of the furnace chamber were therefore removed, and a plentiful supply of air was introduced directly into the tube by means of a silica tube attached to a bellows. The band spectrum then appeared with great intensity. Although pure oxygen has not yet been tried in the furnace, it is fairly certain that the banded spectrum is brought out by the oxygen of the air, since it has been found with the arc that an atmosphere of nitrogen suppressed the bands.

When the bands were made strong in the furnace, the line spectrum, at least in the yellow and red region under examination, was rendered very faint, as if all the titanium vapor were turned into the oxide and this gave the band spectrum alone. No decided change in temperature was evident when air was used in the tube.

It may be noted that this use of the furnace produces what may be regarded as a very hot flame spectrum, since the metallic vapor in the tube is raised to a high temperature and the oxygen is then supplied for the flame effects.

Experiments with the furnace in vaporizing magnesium and calcium in an atmosphere of hydrogen confirms the arc results as to the effect of hydrogen in bringing out the bands ascribed to the hydrides of these elements. Both sets of bands can be produced faintly with the furnace pumped out, but the spectrum of the "tube-arc" has shown that considerable hydrogen is present under such conditions, probably occluded by the graphite tube. The use of hydrogen in the furnace chamber at different pressures and temperatures gave rather variable results until the method was adopted of passing a stream of hydrogen through the furnace tube during the exposures, the pressure in the chamber being maintained at from 10 to 20 cm of mercury. The bands were then obtained moderately strong without, however, any perceptible weakening of the line spectrum. The best defined bands in these bands are at λλ 4845, 5211, 5621 for magnesium and λλ 6382, 6289 for calcium. A temperature not higher than 2200° C seemed to be most favorable for them. At 2500^c the bands were weaker and were liable to appear in absorption, as if they were given by the cooler vapor near the end of the tube.

These results indicate that the strengthening of the titanium, magnesium, and calcium bands by the presence of oxygen or hydrogen, observed in the arc experiments, does not depend on an alteration of the arc discharge by the surrounding gas, and point to the formation of a compound at moderate temperature in each case.

ARTHUR S. KING.

The Maharaja's Observatory at Trivandrum.—The existence of an Astronomical, Magnetic, and Meteorological Observatory at Trivandrum may not be widely known, as it ought to be, outside India, as its name does not appear in any of the Nautical Almanacs published. With a view to draw the attention of the scientific, especially the Astronomical world, I consider it necessary and beneficial, in the interests of the Institution, to request you to insert a short article regarding this most useful institution, in the next issue of your widely circulated Monthly though it may be after 80 years of its chequered life.

Subjoined I give you, for your information, a few salient points connected with its growth.

The institution owed its origin, in 1835, to the enlightened views of His Highness Rama Varma, the then Maharaja of Travancore and to the encouragement given to it by the late General Stuart Fraser, an Astronomer, then representing the British Government at Trivandrum, the capital of the State. It was Mr. John Caldecott, then Commercial Agent to the Travancore Government at the important sea port town of Alleppey, that first brought to their notice the advantages that might accrue to science by the establishment of an Institution like this, in the most southern part of the Indian Peninsula.

It is considered to be a very important one, being very favourably situated, in the language of a former eminent Dewan of the State, "for the purpose of many scientific enquiries." Mr. John Caldecott in the concluding remarks to his Astronomical Ephemeris for 1837 adapted to the meridian of the Trivandrum Observatory—the only production of its kind in India then—"expressed his earnest hope that this Observatory might take an important part in celestial research and prove useful to science." And Mr. John Allan Broun the next Director wrote in his able report that it offered special advantages in the department of terrestrial Physics, or generally terrestrial magnetism, as the Magnetic equator passes through the country" about 90 miles north of the Trivandrum Observatory.

It is provided with all the necessary and some very valuable instruments required for equipping a first class Institution, though old yet mostly in working condition, while some have been otherwise disposed of and a few become unworkable, through long disuse.

Mr. John Caldecott F. R. S., F. R. A. S., a distinguished Astronomer and its first Director and his successor Mr. John Allan Broun F. R. S. formerly of Makerston Observatory near Edinborough and subsequent to his retirement, two native Assistants J. Kochukunju and E. Kochiravi Pillai conducted a series of very valuable Magnetic observations for a number of years. These observations were acknowledged to be of great scientific value and were subsequently checked, and on the representation of the Royal Astronomical Society of Edinbourgh, published in England, in a splendid volume by Mr J. A. Broun, at the cost of the Travancore Government. The Meteorological observations were published by the Meteorological Department, under the authority of the Government of India, in a series of periodical issues forming volumes VII, VIII X of the "Indian Meteorological Memoirs."

Long after the retirement of Mr. J. A. Broun, the Observatory was placed under the guidance of Dr. Mitchel F. R. S. E., Principal of His Highness The Maharaja's College and afterwards Director of Public Instruction, Travancore; and on his retirement from the Travancore service, Mr. Joseph Stephenson B. Sc., his successor in the chair of Physics in the Royal College, took charge. He is now on furlough for one year; and during the period, the Institution is under the management of the Assistant Director, Mr. Rama Varma Raja, who is a born astronomer and "a lover of his work."

The work done in the Observatory consists of:—

(a) taking Meteorological and Magnetic observations and publishing the results weekly in the Travancore Government Gazette;

(b) despatching daily Weather Telegrams to Madras, Bombay and Simla Meteorologists;

(c) compiling Meteorological statistics of Travancore and sending to the Meteorologist, Madras for incorporation in his daily, monthly and annual Reports;

(d) firing, morning, noon, and night time guns at the Nayar Brigade ground, half a mile distant, by means of an electric attachment placed in front of the Mean Solar Time Clock in the Observatory, corrected and reduced by Transit observations. The error of the clock is + .5^s a day; and

(e) Making Astronomical observations from time to time.

The Trivandrum observatory is geographically located

in Lat. +8° 30′ 33″ N

Long. from Greenwich — 5^h 7^m 59^s East, reckoned by the first Director, Mr. John Caldecott. The height of the surface floor above the sea level is 197 ft.

The building is put up on the crown of a conical hill commanding an extensive and beautiful view of the surrounding country up to the sea on the west and on the east the Ghauts, in one of the highest peaks of which, known as the Agustia Malai 6200 ft. above sea level, in Lat. 8° 37′ North and Longitude 77° 20′ east of Greenwich, stood another Observatory from which many observations by means of signalling, were simultaneously taken, and embodied in the Report of Mr. J. A. Broun and in the Indian Meteorological Memoirs Vol. X.

RAMA VARMA RAJA.

Publications Received.

The Field of 61 Cygni, *Mary Murray Hopkins.*

The Amateur Chronologist, *F. Grade.*

Publications of the Dominion Observatory, Ottawa,

Vol. II, No. 10, Gravity

11, Tests made to ascertain where conditions were most suitable for the 72-inch reflector.

12, Mean distance of stars whose radial velocities, proper motions and parallaxes have been determined.

13, Orbit of B. A. C. 5890.

14, Orbit of μ Persei.

Publications of the U. S. Naval Observatory, second series, Vol. IX, Part II, nine-inch transit circle observations, 1903-1908.

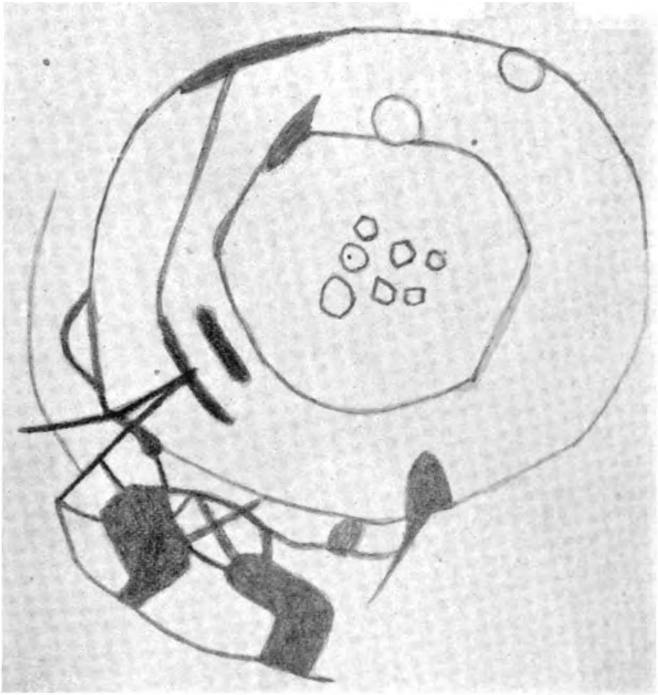
Clock star list for 1916, Royal Observatory, Greenwich.

Arequipa Pyrheliometry, *C. G. Abbot.*

The variation with temperature of the electric furnace spectra of cobalt and nickel, *Arthur S. King.*

Studies of magnitude in star clusters I. On the absorption of light in space. *Harlow Shapley.*

Studies of magnitudes in star clusters II. On the sequence of spectral types in stellar evolution. *Harlow Shapley.*



THE LUNAR CRATER ARISTILLUS.
DRAWN BY WILLIAM H. PICKERING, OCTOBER 19, 1915.

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THE ARISTILLUS TEST FOR PLANETARY DEFINITION.

WILLIAM H. PICKERING.

Apparently the first person to see the double canal on the outer slopes of Aristillus after its existence had been announced in POPULAR ASTRONOMY, Report on Mars No. 5, was Professor Aitken, making use of the 36-inch telescope of the Lick Observatory. He accurately describes the appearance of the outer canals, but after a year's trial, has written me that he had given up as hopeless any attempt to see the duplication within the crater. This is doubtless on account of the large aperture of the telescope, which would require marvelously good seeing in order to be used to advantage for such a purpose. The same reason probably explains the failure of Professor Barnard to see it, who wrote me he should try to do so.

The first persons to confirm the resolution of the canals within the crater were Dr. Lowell and Mr. E. C. Slipher as we have seen in the very excellent set of drawings published in the February number of POPULAR ASTRONOMY. Figures 2 and 4 are the most complete for the outer slope, and show a number of fine canals, some of which are more difficult than the interior double itself. For comparison a sketch (Plate XIII) made here at Mandeville is given which was drawn 1915 October 19, colongitude 50°.4. The region of the little cross below the inner canal, contains some of the more delicate features.*

There are three statements in Mr. Slipher's paper and three only that seem to require comment. One is that the canal varies in breadth and density in different portions of its length. This is true only when it is fading out, and becoming confused with the shadows towards sunset. This is very well shown in his Figures 3, 4, and 5. When the canal is forming, as in his first, and in Dr. Lowell's drawing, the canals are straight, narrow, and perfectly uniform in breadth, very like indeed some of the finer canals visible at the present time upon Mars. Towards noon, that is at full moon, the canals darken and broaden, as is shown in his Figure 2; indeed they soon broaden so much that the space between them becomes practically filled up. Mr. Slipher's second statement is that the canal disappears for a few hours before and after the time of full moon. This is precisely what would happen, and what would be expected to happen if the canal were due to shadow. Indeed this statement would be of the utmost importance if it were true. Unfortunately for that explanation however it is not true. Indeed the exact reverse occurs, as anyone who is interested in the matter may see for himself even with a 3-inch telescope, since at this time the canal becomes very conspicuous where it crosses the crater's rim.

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* See also The Double Canal of the Lunar Crater Aristillus. POPULAR ASTRONOMY 1914 22, 570.

Between the time that the Sun crosses the meridian of a crater and the time of full moon shadows within it are geometrically impossible. The sun crossed the meridian of Aristillus this past March at 18^d $12^h.0$ E. S. T. The moon was full March 19^d $0^h.4$. For these twelve hours the crater was necessarily shadowless as seen from the Earth. Observations made on the evening of March 18 after midnight showed the canals particularly broad and intensely black. Therefore they could not be due to shadow. This particular observation had of course been made here many times before, since it is a perfectly obvious precaution which is always taken to avoid the confusion of patches of vegetation with shadow. It is only mentioned here now in order to give a recent concrete contradiction to the statement in question. The canal was also easily seen in the 3-inch finder with a magnification of 90. Since it was conspicuous both inside and outside the crater rim at this time, while for a few days at sunrise it is certainly invisible outside, and for a few days towards sunset is certainly invisible inside the rim, it is clear that it cannot owe its existence in any way to shadow. The third statement that the canal crosses the floor of the crater is also incorrect. It originates about half way up the interior north-western wall, and instead of going down onto the floor, then proceeds north-westerly up over the rim.

These corrections are of little consequence, as I believe no one at the present day attributes the canals and variable spots visible at full moon to shadow, but they are refuted here simply because they accompany a plate containing some very excellent drawings of a very interesting object, and for that reason it seemed desirable to correct them. Up to date it is believed that Dr. Lowell, Mr. Slipher, and the writer are the only persons who have succeeded in dividing the interior canal. In a recent letter from M. Jarry Desloges he states that it is being observed from his station at Setif in northern Africa, and since the atmospheric conditions there are clearly of very high quality, there is little doubt but that the division will be accomplished there also.

While it will be clear from what has preceded that this is a pretty difficult test of planetary definition for the average observatory, and one which it is hopeless to attempt to achieve with an aperture of much less than 8 inches, or a magnification of less than 300, yet it must be recorded as the writer's opinion, that it is doubtful if any duplication on the planet Mars will prove as easy as this lunar canal. It is true the writer has not seen any double canals as yet upon Mars, and for that reason still remains a little skeptical about their existence, especially since the past two oppositions are precisely the ones when according to Schiaparelli they should be most readily visible. He can state however that it is certain that neither at this opposition nor at the last has there been any double canal on Mars as readily visible as that seen in Aristillus.

A few of the Martian canals such as Thoth, Nilosyrtis, and Cerberus are obviously more conspicuous than those on the outer slopes of Aristillus, when we view first one and then the other under similar conditions. On the other hand the great majority of the Martian canals are much fainter, and their duplication would certainly be more difficult. Therefore it is plain that no observer whose equipment and atmosphere make it impossible for him to divide the interior canal in Aristillus has any right to express an opinion as to the existence of double canals on Mars.

Under favorable conditions the resolution of the canal in the interior of Aristillus is always possible between colongitudes 35° and 65°, and between 110° and 140°. It is therefore visible on from four to six nights out of every lunation, and should any other observer succeed in seeing it, I hope that he will inform me, since it is very desirable to know at what other observatories in the world besides at Mandeville where it was discovered, and at Flagstaff where it was confirmed, the really best atmospheric conditions are to be found.

Mandeville, Jamaica. B. W. I.
March 22, 1916.

THE MOVEMENTS OF THE MOON

J. PERCY JOHNSON.

Certainly, the Moon is the most lovely orb of heaven, and richly deserves the title bestowed upon her by the poets—"Queen of the Night." There is no other heavenly body, with the possible, but doubtful, exception of the Sun, which is subjected to more observation by "the man in the street," and there can be little doubt that this is chiefly due to her peculiar beauty as she presents her varying phases to our view, and to the pale soft loveliness of a moonlit landscape, which is more entrancing than the warmth and brilliance of one illumined by the glory and splendour of "King Sol" himself. Who has not beheld with pleasure the slender crescent of the young Moon in the evening sky, or gazed in rapture on the heaving waters of the ocean glistening under the silvery moonbeams?

The Sun may be the grandest, the most important object in the Universe so far as the inhabitants of the Earth are concerned, in their dependence upon the beneficence of His Majesty's rays; the great nebula in Orion may be the most awe-inspiring spectacle astronomers have ever looked upon; Saturn, with its wonderful rings, may be the most unique revelation of the telescope; but—upon this, I think, all are agreed—the gentle loveliness of our faithful satellite, the Moon, is unequalled in the realms above.

In which of her many changing aspects does the Moon most delight the eye of man? Is she most lovely of all when seen in the beautiful western sky at sunset,—an exquisite crescent with "the Old Moon in her arms,"—or when serenely "sailing" high in the heavens, 'mid the fast flying clouds, she shines o'er land and sea, investing every scene with a beauty all her own, or is the great, golden Harvest Moon of autumn, rising night after night in the north-eastern sky about the time of sunset, the loveliest of all the lunar phases?

Who shall say?

In addition to this wealth of beauty, manifest to the most casual observer of Nature, the Moon has many attractions which merit much attention, and which arise mainly from the fact that she is our nearest neighbour, and can be subjected to a closer scrutiny than can any of the other denizens of space.

To the amateur astronomer possessed of a telescope, the Moon is certainly the most beautiful of celestial objects, and he can sit for hours at his instrument, reveling in the unsurpassed glories of the lunar landscape. To one who looks at the Moon telescopically for the first time, the sight is a never-to-be-forgotten one. The jagged line of mountains, dividing day from night, catching the sunlight on their top-most peaks, looks like a row of snow-white crystals, or shining jewels, and never fails to draw forth exclamations of surprise and admiration. The strong contrasts of light and shadow are a never-ending source of delight and wonder,—the shadows streaming across the plains, and revealing in exaggeration the contour of the mountain ranges.

The Moon's interest, however, lies not only in her telescopic appearance, a description of which, unfortunately, cannot be included in the present article. With the single exception of the Sun's apparent movements athwart the heavens, the Moon's varying position among the stars, with the accompanying change in her phase of illumination, is the most obvious and striking of all astronomical phenomena, and one which has attracted the notice of man from times of the remotest antiquity. Although the earliest records extant in this connection are merely the expression of a primitive wonder and simple nature-worship, they are exceedingly interesting, and deserve more than the passing reference here made. They take the form of hieroglyphic inscriptions which the Egyptian races, of probably 6,000 years ago, left on their temple walls, showing us that the Sun, Moon, and stars, were then regarded with a seriousness we would do well, to a certain extent, to imitate. At that early period in the history of mankind, about which much might be written, the stage of thought was primarily that of worship, as is shown by the evidence of the deification of the various celestial bodies to be found on every hand in the majestic ruins of the vast and mighty buildings in that strange land on the banks of the Nile.

There is also ample evidence, however, that the utilitarian point of view was not neglected,—indeed, it was more important than we are apt to realize in these days of calendars. This is conclusive in the case of the Sun, whose variations were sedulously watched by the priests, both for religious and mundane purposes, and it is certain that the convenient division of time marked by successive lunations would direct an equally scientific attention to those of the Moon. In one of the inscriptions referred to, the waxing Moon is typified with that charming simplicity which always characterizes these pictorial writings, but which very simplicity often baffles the best brains for an explanation. It is known as "The Square Zodiac" of the chief temple of Denderah, and shows the moon-god at the top of a flight of fourteen steps, which symbolize both the Moon's increasing phase, and the number of days between "New Moon" and "Full Moon"! In another representation, the god is divided into fourteen pieces to illustrate the phenomenon of the waning Moon!

In parenthesis, it may here be allowable to emphasize the better perspective of awe and wonder which obtained in those far off days, when even the succession of day after night was looked upon with feelings of doubtful confidence, than does with the majority of people today. Although it would be foolish to compare the vastly superior knowledge possessed by the public in general, and astronomers in particular, in the twentieth century, with that superstitious regard held by the ancients, it is, at the same time, that very excellence of the learning of today which is responsible for the careless indifference of the many too fundamental facts of nature.

These may not be of so recent discovery as, for example, the so-called "canals" on Mars, and may not be so sensational to the popular mind, but they are, nevertheless, among the most impressive things in the Universe, fit food for the deepest thought and meditation.

All the heavenly bodies, Sun, Moon, planets, and stars (and comets too, when they happen to be visible) daily perform an apparent revolution round the earth, due to the latter's diurnal rotation on its axis. The general ignorance which prevails respecting this motion of the stars is remarkable, but it will come as a shock to many readers when it is stated than many persons are entirely unacquainted with the Moon's regular performance of this apparent daily motion. (The word "apparent" is used to signify that the movement is not real on the part of the Moon, but is similar to the apparent motion of objects seen from the window of a traveling train). The extent of their knowledge seems to be confined at the most to three weeks out of every month. What becomes of our satellite during the remainder of each period, remains with them as great a mystery as the Sphinx, and, it might be added, as far as they are concerned, matters less! Surprising as it may seem, the writer has heard the greatest wonder expressed by otherwise intelligent persons at what should be the familiar sight of the Moon in her First Quarter in the afternoon sky. Such complete indifference to natural phenomena, whether "in heaven above......in the earth beneath, or in the waters under the earth," is not justifiable. It is our duty as intelligent creatures inhabiting this planet to take reasonable notice of what is taking place around us.

Let us, therefore, attach our interest to the common, but beautiful spectacle of the crescent Moon in the evening sky at sunset, watching night by night her progress among the twinkling stars, and try to realize something of the feeling which animated those who carved that simple note on the temple stone at Denderah, which will endure when this printed page, and the material bodies of those who read it will have passed into oblivion.

In the first place, it is interesting to discover how soon the Moon first becomes visible after the time given in calendars as that of "New Moon." Previous to this, although the Moon is in the immediate vicinity of the Sun, she is lost in his superior lustre, and we are apt to forget her presence until we are apprised of the fact by her withdrawal to a sufficient distance to permit her illuminated rim to be glimpsed. Theoretically, the completely dark "New Moon" should be of brief duration, and quite a degree of enthusiasm may be introduced into monthly searches to secure earlier detection of the exceedingly delicate crescent she presents on her first appearance after emerging from the overwhelming brilliancy of the great luminary. Under the conditions of such early observance, she will be disclosed in the evening by the diminution of the Sun's powerful light, but, following the example of her grand-parent, she sets almost immediately. Carried by the diurnal rotation of the heavens beneath our feet, she rises soon after the Sun the next morning, and will doubtless be apparent in the sky throughout the day. It will be observed that the convex surface of the crescent is presented to that part of the sky in which the sun is situated. It is surprising how many artists spoil what otherwise might be good pictures by neglecting such an observation as this, and erroneously depicting the concave side turned towards the place of sunset, thus betraying their ignorance of the source of the borrowed radiance of the "Lamp of Night."

Once again the Sun sinks in the golden west, and the shades of evening commence to fall. As twilight deepens into dusk, the Moon, now appreciably advanced in phase, and occupying a position further to the east than that of the previous evening, though sinking in the heavens, lingers yet awhile, an object of rare beauty and delight, hanging in the vault of heaven like some phosphorescent ball of liquid light set in a silver bowl.

"The Old Moon in the New Moon's arms—"

so familiar! so charming!

It may be noted in passing that the bright crescent often seems to belong to a distinctly larger body than the remainder, which accentuates the appearance above referred to, especially when the Moon is "on her back," to use a popular expression.

This is an optical illusion, due to irradiation, by virtue of which, a light body projected on a dark ground appears to be larger than it is.

In the spring of the year, by reason of the oblique angle at which our satellite's path meets the horizon, the young Moon remains in the sky, many hours after sunset; but eventually, whether sooner or later, as our hemisphere of this ponderous earth turns over for its night's repose, the horizon rises up and cuts her off from view, depriving us of her reflected rays, which, although so mild and gentle, have hidden the full glory and splendour of the starry firmament.

A similar sequence of events takes place during the next twenty-four hours, with the result that the moon is discovered still further to the east, and more fully illuminated. When she happens to be near a star this motion, which is known to astronomers as "direct" motion because it is the Moon's real movement as distinguished from that "apparent" daily rising and setting motion, is easily noticeable in the course of a couple of hours. The distance between the Sun and Moon is thus steadily increased by this persistent movement to the east, and the illuminated portion of the latter's disc is constantly directed to the former's. When about seven days old, the Moon is in her "First Quarter" and about the time of sunset is on the meridian,—the line which passes through the zenith and the north and south points of the horizon. The gibbous phase is now entered upon, and every night the Moon continues her journey to the east, until "Full Moon" is attained, when she rises at the time of sunset, and is on the meridian at midnight. Of course, when it is said that the Moon is further to the east, it must be understood that it is so at the time of our initial observation, which in this case was sunset, as the daily rising and setting motion, due to the Earth's own rotation, carries it through all positions in the course of a day.

The phase now decreases, and it will be seen that the illuminated part has "faced about" and is now directed to the eastern sky. When she has reached her "Last Quarter" the Moon does not rise till about midnight and at sunrise is on the meridian in the morning sky. During the next seven days she approaches closer and closer to the Sun until a very fine crescent is attained, when she is seen only in the strong light of dawn in the east. Then she is lost in the Sun's rays, to emerge shortly afterwards as a brand "New Moon" in the west!

This is the monthly cycle of the Moon's changes, and although some may smile at such a laboured description of what they think is of such common knowledge, the writer is content to let it stand in view of what was remarked in the early part of this article. Very little consideration of the above observations will convince one that the Moon's light is not an inherent property, but that she is a dark, globular body reflecting the Sun's rays, whilst the only explanation of the "backward" motion from west to east (which truly is "real" and "direct" motion), which has been distinguished from the daily movement from east to west (which truly is only "apparent" and "retrograde"), is that the Earth's satellite is revolving round its primary in a period of about four weeks.

According to Professor Newcomb both these facts have been known from the earliest times.

That her light should be so white need occasion no surprise when one thinks of the pure whiteness of the clouds, which at other times, when not reflecting the solar rays, are so dark and forbidding. It has been variously estimated, however, with regard to the intensity of the lunar beams, that from 300,000 to 600,000 "Full" Moons would be required to produce the degree of illumination experienced by the earth on a bright summer's day!

Let us now consider more closely the period taken by the Moon to complete her orbital motion. Subsequently we shall deal with the dimensions of that orbit and certain variations in its form, which, though minute, are of great interest and importance, and were known thousands of years ago.

It has been mentioned that the interval of time between two successive "New" Moons is about four weeks. Actually, the average period is 29½ days, but this does not represent the time taken to make a complete circuit of the Earth. It is too great, for this reason: The Sun, like the Moon, has an independent movement apart from the daily rising and setting motion, which carries it from west to east. This is, however, not a "real" motion on the part of the Sun, as was the Moon's, but an apparent one due to the Earth's yearly journey in space and consequent projection of the Sun on every part of a great circular belt on the background of stars, known as the Zodiac. That is to say, the Sun has a "backward" (direct) movement in the sky like the Moon, but a much slower one, which only carries it through in a year, what the Moon can accomplish in a month. Therefore, when the Moon arrives at that point in the great pathway of the stars at which she was last "new" she has circled the Earth completely, but the Sun has apparently moved further to the east, and it takes the Moon a little over two days to "catch up" and become "new" once more.

The first of these, the true period, because it may be referred to the position of the Moon in the stars, which for this purpose may be regarded as forming a changeless background or dial, is termed the "sidereal" month. The second, or interval between two similar phases is called the "synodical" month. The length of the sidereal month is 27d., 7h., 43m., 11½s., whilst the synodic month is, as has been mentioned, 29½ days. There are, however, several minute variations which render this statement liable to slight modification, as will afterwards appear.

The Earth's annual motion round the Sun, we have said, causes the latter to appear in various parts of the background of stars which is situated at an infinitely remote distance in comparison to those of both Sun and Moon. The constellations in which the Sun successively appears (or indeed would do so if his light did not hide them) are the well known twelve signs of the Zodiac—Aries, Taurus, Gemini (The Ram, the Bull, the Heavenly Twins) etc., and its actual path which runs through this belt of the Zodiac is called the "Ecliptic". Its position is obviously determined by the direction of a line from the Earth to the Sun, and continued to the starry dial. As the Earth proceeds on its annual voyage round the Sun, this imaginary line will sweep round in a plane, which is "the Plane of the Ecliptic", or the plane of the Earth's orbit. This plane is marked out then by the Sun's path in the sky, which can be accurately marked down on a map of the stars.

Now the Moon marks out its own track in the sky, and this can also be marked on the chart of stars. It is found on so doing that the Moon's path cuts the Sun's path or Ecliptic at an angle of five degrees.

Therefore, part of its monthly journey is above the plane in which Earth and Sun are situated, and the remainder is below that level. That point at which the Moon commences to rise above the Ecliptic is called the "ascending node," and that at which it begins to descend below it, the "descending node." It is apparent that once a month when the Moon is "new," it must occupy a position somewhere between the Earth and the Sun, and it is further quite clear that if she were *directly* between the two, or *in the Plane of the Ecliptic*, she would "eclipse", or interrupt the Sun's light.

We have seen that the Moon is in the plane of the Earth's orbit at two points only, the nodes, so that when an eclipse occurs, it is certain that one of these nodes lies in a position exactly between the Earth and the Sun. If this node were fixed in that position, an eclipse would occur regularly every month at "New Moon," but as eclipses are not of such regular occurrence, it follows that the Moon when occupying a position intermediate between the Sun and Earth, it is generally a little too high above the Plane of the Ecliptic, or a little too low down below it to be in an absolutely straight line between the two and cause an eclipse.

It is perfectly plain, therefore, that the position of the nodes is not constant,—in fact, it has been found that these points are gradually changing their positions, and that in about 18½ years they make a complete revolution of the Moon's orbit. A good idea of the effect of this on the plane of the Moon's orbit can be obtained by spinning a plate on the ground. Just before it is about to collapse flat on the floor it will present a fair representation of what is taking place, each "wobble" corresponding to an 18½-year revolution of the nodes. Naturally the recurrence of eclipses of the Sun and Moon depends upon this phenomenon, as an eclipse of either of these bodies can only happen when the Moon is at one of its nodes or a certain definite distance thereof, (1) at "New Moon" and (2) at "Full Moon." Taking the case of solar eclipses:—If no other circumstance had to be taken into account, an eclipse could happen only once in 9¼ years, or the time taken for a node to make half a revolution and occupy the position previously held by the other node. While this backwark movement of the nodes, which amounts to one and three-fifths degrees a month, is taking place, however, the Sun's position is moving forward (W to E) at the rate of 30 degrees a month, so that at the end of that time the node is removed from the Sun's position thirty one and three-fifths degrees, and in five and three-fifths months 180 degrees will separate the two positions. This means to say that the other node will now be in front of the Sun, and the conditions for an eclipse again occur, so that two eclipses must occur within six months. We have assumed, however, that the node must be directly between the Sun and the Earth. This is not quite true, as the Sun and Moon are not mere points, but have a magnitude, so that if the node is sufficienly near to permit their respective disc edges to overlap a partial eclipse will be visible, whilst the magnitude of the Earth allows an observer to move about to various vantage points and still further increase the frequency of eclipses of the Sun. Indeed, eclipses of the Sun are of more frequent occurrence than eclipses of the Moon, *if the observer is always able to be on that part of the Earth from which the solar eclipse is visible*, but if he is not able to move about in this way the lunar eclipses become the more common, for, whilst the belt of Earth permitting observation of the former is narrow and is continually varying its position, the latter, when visible, is so from every part of a whole hemisphere of the Earth. From what has been said it will be seen that, far from an eclipse happening only once in 9.3 years, a regular series of eclipses will be possible under the conditions laid down, but that after 18.6 years this series will start all over again and the eclipses will all be repeated at successive intervals of time similar to those in the previous series.

The Chinese of two thousand years ago recorded eclipses, but not systematically, whereas the Chaldeans were well acquainted with the period we have been discussing, which they termed the Saros, and were thus able to predict the recurrence of eclipses more or less truly.

This period, however, is subject to slight modification owing to small variations which have not been dealt with, and it was subsequently improved upon in 432 B.C. when the Metonic Cycle was introduced with a much smaller degree of error, whilst in 330 B. C. Callipus made a further improvement by which all eclipses, and the day on which they would occur, could be predicted for years to come. All these results were solely from observations of eclipses and it was reserved for Hipparchus (190-120 B. C.) to discover the dimensions and nature of the Moon's orbit and the revolution of the nodes in 18⅔ years,—remarkable achievements 2,000 years before the invention of the telescope!

The Moon's distance, this wonderful astronomer found, by parallax, to be 59 times the radius of the Earth,—a practically correct result, and he also rightly determined the inclination of the Moon's orbit to the Ecliptic to be five degrees.

The problem of the Moon's distance is more suitable for inclusion in an article dealing especially with the measurement of planetary distances, and will therefore not be dealt with in the present article. Angular measurements on precisely similar principles to those underlying the work of surveyors have revealed that our satellite is situated at a mean distance of 238,840 miles. Such measurements conducted when the Moon is in various parts of its orbit show that although viewed from the point of view of its magnitude the orbit is practically circular, (as is also shown by the fact that the Moon's apparent diameter is subject to no great variation), it is not exactly so. The Moon occasionally retreats to a distance of 259,600 miles, whilst at other times her distance is reduced to 221,000 miles.

Hipparchus, by comparing the intervals between eclipses, discovered that the Moon moved faster in some parts of her orbit than in others, and was so led to infer the ellipticity of her path.

Other variations of the Moon's motion may be briefly mentioned. The two points at which the Moon is least and most removed from the Earth (perigee and apogee), by virtue of orbital eccentricity, are found to have a motion opposite in direction to that of the nodes (direct, therefore) which carries them completely round the orbit in 8.8 years. This is caused by the disturbing influence of the Sun, which also has another effect, discovered by Tycho Brahe, namely, that of retarding the Moon's velocity, so that the sidereal month, which, as has been explained, is the true period of the Moon's revolution round the Earth, is an hour longer than it would be if the Sun could be imagined to be absent.

The Earth's path round the Sun is also elliptical however so the Sun's distance is a variable quantity. His retarding influence is therefore variable accordingly, *and although the net result is as stated above*, the Moon gets ahead of or falls short of her mean position (i. e. the position she would occupy if the Sun had no disturbing effect) according as the Sun's distance and influence is lesser or greater, by an amount known as the "annual equation." Now although all these perturbations were explained by the great and immortal Sir Isaac Newton on gravitational principles, there are others of an exceedingly minute, but none the less definite character, which mathematical science is not yet in a sufficiently advanced condition to account for—and that is saying a good deal. Although in the present article the writer has left the Moon's telescopic appearance strictly alone in order to avoid undue length, certain facts must be noted in connection with the movements of our attendant satellite. In the first place, the Moon always presents the same hemisphere towards the Earth,—three sevenths of the Moon's surface has never been seen by man, and never will be.

The reason for this is, not that the Moon has no axial rotation, but that the period of that rotation is the same as that of her revolution round the Earth. In other words, in going round the earth once, the Moon turns on its own axis once. Many people experience a difficulty n appreciating this fact, which may be readily understood by the following performance:—

Regard some object in the centre of a room, such as a table, as the Earth, with oneself to represent the Moon. Move around the table once, keeping the face always turned towards it. Now, although one has never turned the back towards the table, it is evident that not only has one encircled the same, but that every part of the room has been faced in turn. That is to say, whilst performing the motion of revolution, a concomitant one of "axial rotation" has also been performed. This is exactly analogous to the case of the Moon.

It has been mentioned that only three-sevenths of the Moon is visible from the Earth, which of course means that *more than one half is visible*. It is now to be seen how the extra little bit (one-fourteenth) is caught sight of.

It is due to three causes, viz., longitudinal, latitudinal, and diurnal libration! In the language of astronomers, how terrifying all that seems. In reality, it is quite simple. Libration in longitude is an apparent swinging of the Moon to the E and W and it is brought about owing to the facts that while the Moon's rotation on its axis is steady and constant, its movement in space is unequal, as we have seen, sometimes it goes quicker than at others. When it goes quickly, we catch a glimpse round one side, when it goes slowly we get a look just a little tiny way round the other side. Libration in latitude is an apparent swinging of the Moon to the N and S. This is brought about by the two circumstances that the moon's orbit is inclined to the ecliptic at an angle of five degrees, and that her axis is inclined to her own orbit a further 1½ degrees, the effect being that the Moon is now tipped with the N pole 6½ degrees towards us, and when at the opposite side of her orbit, she has her S pole tipped 6½ degrees towards us.

Diurnal libration adds to longitudinal libration in that we see further to the east and west of the Moon than we would do without it. It is due to the Earth's own daily rotations, which carries an observer to and fro enabling him to extend his views to the right and left of the Moon's face.

It will probably have been noticed by most readers that when, in summer, the nights are practically never dark, and there is no great need for the Moon's light, that is the very time she attains her least elevation above the horizon, and therefore sheds the least light; whereas, when the nights are long and dark, she attain her greatest elevation and we receive the best possible benefit from her rays. "Pat" was fairly near the truth, accordingly, when he replied to the question as to whether he preferred the Sun or the Moon, that the Moon met with his preference, as she shone in the night when she was needed, but the Sun shone in the day, when anybody could see!

The reason for the Moon's varying summer and winter altitudes may be seen if we consider her when "new" and when "full". When "new" she is close to the Sun, and in midsummer, the Moon's greatest elevation is attained when the Sun is highest in the heavens, at mid-day. Like the Sun, the Moon has by far the greater part of her path above the day-time horizon. When the Moon gets round to the opposite side of her orbit, and to the "full" phase, it is the remaining and smaller section of her path which is raised above the night-time horizon, and she therefore reaches no great elevation. In winter, the Moon when "new" is again close to the Sun, which is this time in its lowest position in the heavens. When the "Full Moon" is reached she is in the larger section of her orbit and at midnight is high in the sky. In effect, the Moon when full is always in that part of the sky which will be occupied by the Sun in six months' time, and it may have been noted—what never fails to strike the writer—that on a bright moonlight night in winter, the shadows of a landscape produce the impression of a ghostly summer scene at mid-day!

The last subject of remark will be the "Harvest Moon." In the northern hemisphere of the Earth, the "Harvest Moon" is that Full Moon which happens nearest to September 23rd, the date of the autumnal equinox.

Its peculiarity is that it rises for several successive nights at practically the same time, and is supposed to be on that account a help to harvesters.

The Moon has not ceased to perform its persistent motion from W to E, which has been discussed, by virtue of which it is 51 minutes later arriving at the meridian every night. That movement continues the same as before, but its effect in retarding the rising hour of the Moon is nullified because at the time of the equinox the path of the Moon cuts the horizon at a very oblique angle, so that the movement is almost horizontal and carries it very little further below the horizon for several nights.

A great deal more might be said about our interesting satellite. Her wonderful telescopic aspect, her mountain ranges, plains, craters, rills and rays, her questionable influence on the weather and on disease, her control of the tides,—all these might be dealt with, but each would require an article by itself.

If readers are induced to look with more interest on the calm and peaceful Moon, and think with wonder of the marvelous multiplicity of the variations of her movements in adjustment to grand and simple laws of gravitation then this article will not have been written in vain.

Douglas, Isle of Man.
10 Strand street.

OBSERVATIONS ON JUPITER AT THE OPPOSITION 1915.*

EDISON PETTIT.

The following observations on Jupiter were begun with the Yerkes 40-inch telescope and completed with the Washburn college 12-inch telescope and position micrometer. The observations were made: (1) To determine the rotation period in various latitudes where markings of definite character might be found; (2) to determine the polar compression; (3) on the great red spot; (4) to measure the diameters of the satellites; (5) to determine the character of any markings on the satellites.

General Features.

From twenty five observations a map in Mercator projection was drawn as shown in Figure 1. This takes System II of the Ephemeris as a basis of the longitudes. The quadrant from 180° to 270° was not well observed. Since the planet was near the equinoctial, observations were confined to positions near the meridian. Powers of 750 and 1000 were used on the 40-inch, and all observations with the 12-inch were made with power of 1000. Very clear weather during October and November greatly facilitated observation. Especially clear weather was taken advantage of to measure the satellites which otherwise flared too much.

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* Read before the Kansas Academy of Science.

Almost all the surface features lie between the 30 degree parallels of latitude. Plume-like markings were a quite prominent feature. A peculiar marking was observed on many nights in the southern band longitude 300° to 360°, latitude −15° to −30°, like a grove of trees. Attention is especially called to two small dark spots, the following one in longitude 309°.8, latitude 15° north. This latter is especially adapted to the determination of the rotation period, being small and round and of considerable depth of color. Its actual diameter is 2100 miles, about that of the Moon.

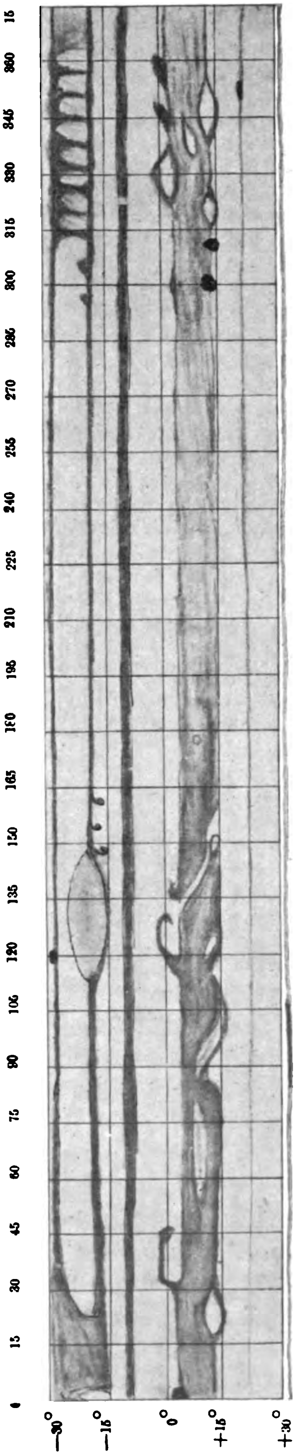

FIGURE 1.

A faint line running around the planet in latitude 32° north is widened to a short thick band on longitude 85° to 105°. This is also well adapted to the determination of the rotation period. The white spots in the neighborhood of longitude 345° were brilliant and in general of a lemon shape.

THE ROTATION PERIOD.

In measuring the rotation period both transits over the central meridian and elongations of the marking were observed. For the transit observations the double value of the equatorial diameter was measured as usual, and the micrometer set to ¼ this value minus ½ the wire correction. As the marking approached the central meridian it was tested by setting first the right then the left wire tangentially till the eye was satisfied that the central meridian had been reached and the time recorded to the nearest tenth of a minute. The elongation measures were reduced to the time of central transit. The reductions show that the elongations will give as accurate values of the rotation period as the transits if the seeing is good enough to permit rapid measurement.

From an elongation of the round spot longitude 309°.8 latitude 15°.0 north on September 21st and a transit of October 29th the value $T = 9^h\ 55^m\ 22^s.16$ was obtained. From transits of the black band longitude 82° to 105°, latitude 32°.0 north on October 26th and November 19th, $T = 9^h\ 55^m\ 40^s.76$ or an acceleration of $1^s.1$ per degree of latitude in this region.

THE POLAR COMPRESSION.

Twenty-five observations were made for the polar compression of which ten were rejected on plotting the residuals. From the fifteen remaining the value 1/17.4 ± 1/270.3 was obtained. This is a probable error of 6.4%.

THE GREAT RED SPOT.

The Great Red Spot was quite distinct at times, showing a dull brick red color. Its measured position was longitude 131°.7, latitude 23°.0 south, length 29273 miles. A peculiar group of plumes follows it. The ends of the spot had quite sharp points.

THE SATELLITES.

On two nights the images were quite free from flaring. The means of the measures are:

I = 2614 mi., II = 2233 mi., III = 3908 mi., IV = 3422 mi.

Markings were observed on III and IV. Attention was especially attracted to III. On two occasions, October 21.419 and October 29.458 C.S.T., a marking was distinctly seen as shown in Figure 2, the angle the straight side of the marking makes with the plane of the planet's equator being 70°. It will be noticed that the time between the observations is nearly equal to the revolution period of the satellite, which seems to indicate that the satellite keeps the same face toward the planet during its revolution and that the marking is always turned away. It will be interesting to see if this feature is a permanet one at the coming October opposition which will be the nearest approach of the planet in twelve years.

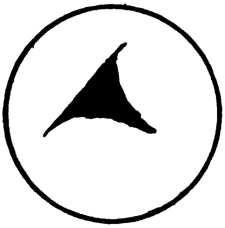

FIGURE 2.

Washburn College Observatory,
Topeka, Kan.
February 21, 1916.

THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

[*Continued from page 218.*]

After reading Galileo's reply to the *Tres Epistolae* as translated through the efforts of Welser, Scheiner wrote a sixth letter* to his patron, dated July 25, 1612. In addition to the customary, "Apelles Latens Post Tabulam", this was signed with the motto, "Ulysses sub Aiacis clypeo." The letter is mainly concerned with the spots. The question of their actual existence, which in Scheiner's mind seems to be still a matter of doubt, is discussed at some length. Two methods of observing, in neither of which a telescope is used, are described, which methods testify that the spots are not caused by the glass. A list of names is given, of observers in Italy and elsewhere who have also seen the spots. Apelles' conclusions regarding the spots are briefly as follows: The apparitions which cause the appearance of spots are not in the eye, nor in the tube, nor in the atmosphere, nor in the heavens far from the sun. They move around the sun at a small distance from it. They are bodies of a thin flat shape, because they diminish their diameter in longitude but not in latitude. They are not to be included among the number of the stars, because their figures are irregular and they vary. They now and then appear in the middle of the sun, and they sometimes disappear before finishing their course. Scheiner compares the observations of Galileo with his own on the same spot, and from their similarity concludes that the spots have no parallax. At the end of the letter he describes an eclipse of the sun which occurred during May 1612. During this eclipse, which was of magnitude seven digits, the moon was surrounded by a luminous aureole. Observing without the telescope, the portion of the moon covering the sun was seen transparent like crystal or glass, and showed the whole of the sun. [!]

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* *Gal. Op.* 5, 57.

In a letter to Prince Cesi, dated May 12, 1612,* Galileo informs him that he has completed a letter (the first) in reply to Apelles, and telling Cesi of his conclusions as already quoted (page 90), states that a copy of this letter will soon be forwarded to him. This in fact took place two weeks afterwards. Some months later (September 14) Cesi again wrote to Galileo† offering to print this letter with another on the same subject, (Galileo's second letter to Welser) a copy of which it appears Cesi had received a short time before.

By this time Welser had had the second series of three letters from Apelles printed at Augsburg with the title, *DE MACVLIS SOLARIB. Et stellis circa Iouem errantibus, ACCVRATIOR DISQVISITIO AD MARCVM VELSERVM......Anno M.DC.XII. Idib. Septembr.* (Plate XIV). A copy of this was forwarded to Galileo on the 28th of September.‡

On the 5th of the following October, Welser acknowledged the receipt of Galileo's second letter.¶ In a letter which has not come down to us, Galileo informs Prince Cesi of his intention of replying to the the *Accuratior Disquisitio.* This reply was sent in the shape of a third letter‖ to Welser, dated December 1st, 1612. In the first part of this letter, which is the longest of the three, Galileo discusses at some length the motion and probable appearance of Venus during transit, which Apelles had "more diffusely explained than in the first letters". He objects to Apelles' proofs by appeal to the common opinions of philosophers and mathematicians, because the opinions of a thousand of these are not equal to the smallest spark of reason, and it is useless to refer new phenomena to the authority of past writers who if they should see the new things, would certainly think otherwise. Galileo then examines the arguments with which Apelles had proved that the spots could not be a part of the sun. Regarding the observations of the spot near the sun's center which required 16 days for transit, and the other in a higher latitude which required only fourteen days, Galileo states that he has made many observations and concludes that all the spots remain on the solar disk for the same space of time, which is slightly more than fourteen days. He criticises the observations, because the spot observed by Apelles was one of a group, and through the irregular changes in the positions of individual spots in a group accidental errors might be introduced. No conclusion can be drawn from a single observation, but only from a comparison of many such. As a result of comparing a large number of drawings and sketches, some slight differences have been noticed in the times of transit, namely, that the spots crossing near the center of the disk travel faster than those farther away. Galileo then proves with diagrams, that if one assumes that the spots are exterior to the sun and moving in one direction with a common motion, and that Apelles' observations are correct, the spots must need be so far distant from the sun that certain other observed phenomena could not take place. The region in which the spots would have to move is found to be distant from the sun's surface by more than its radius, and on account of the peculiarity of their motions this is manifestly impossible. Apelles' own drawings of spots, accompanying the *Accuratior Disquisitio*, are used to prove that the daily motion of the spots is exactly what it should be if the spots were situated on the surface of the sun and it revolved on its axis.

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* *Gal. Op.* **11**, 296.
† *Gal. Op.* **11**, 394.
‡ *Gal. Op.* **11**, 402.
¶ *Gal. Op.* **11**, 407.
‖ *Gal. Op.* **5**, 186.

Apelles had observed the same spot that Galileo had pictured in his first letter, and from the agreement with his own observation asserted that the spot showed no parallax. Galileo objects to this because his observation was not suitable for a comparison, since the drawing simply pictured the spot without indicating its position on the sun, and hence no conclusion could be drawn.

In this letter is the first mention of the "faculae". Galileo calls these small bright spots, and states that since they manifestly cannot be exterior to the sun, and because they show the same motion as the dark spots, the latter must be a part of the sun. He remarks that while Apelles has claimed that the spots are stars, he has taken from them every attribute in which they might resemble the stars. The remainder of the letter contains little of interest regarding the spots. Galileo replies to Apelles' statements concerning the transparency of the moon, whether the earth reflects light or not, the habitability of the planets, etc., etc.

Before this letter to Welser had been finished, the Accademia dei Lincei at a meeting held on the 9th of November 1612, decided that all three letters should be printed by them.* The printing, arrangements for which were made by Cesi, was done at Rome. The progress was slow on account of objections by the Papal Censor to certain passages, and on account of other difficulties; but the publication finally appeared on the 22nd of March 1613.† The choice of a suitable title occasioned many discussions between Galileo and the Lincei; that finally decided upon was, *ISTORIA E DIMONSTRAZIONI INTORNO ALLE MACCHIE SOLARI E LORO ACCIDENTI COMPRESSE*

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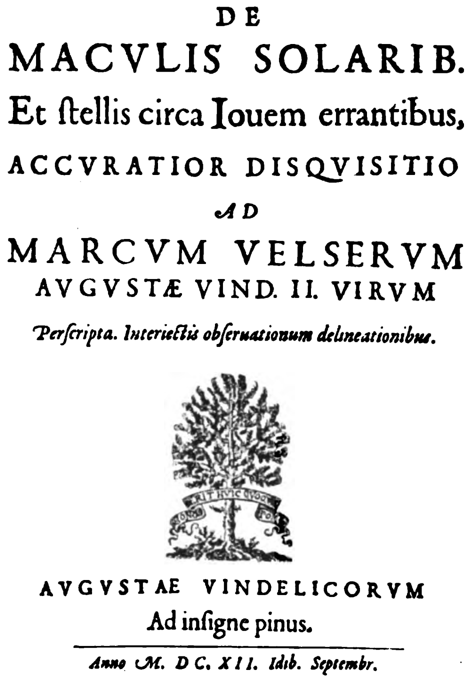
* Domenico Carutti, *Breve Storia della Accademia dei Lincei.* Roma, 1883. p. 32.

† *Gal. Op.* **11**, 489.

PLATE XIV.



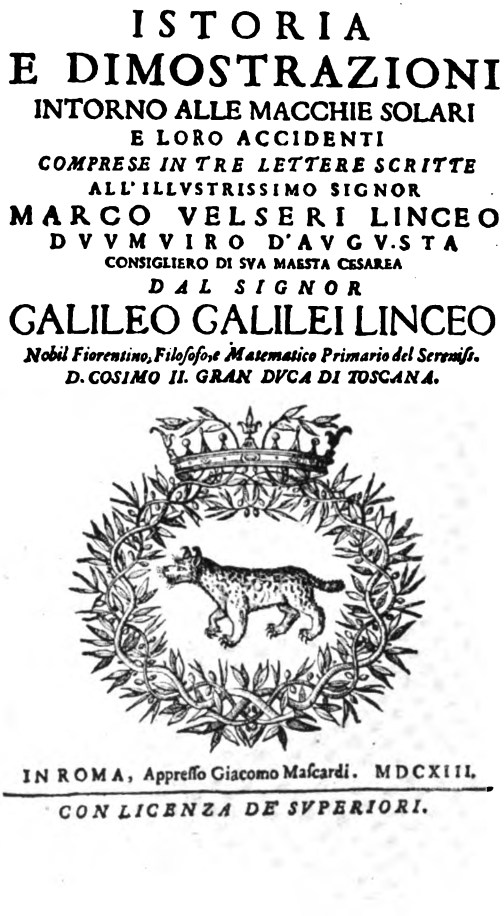
DE
MACVLIS SOLARIB.
Et ſtellis circa Iouem errantibus,
ACCVRATIOR DISQVISITIO
AD
MARCVM VELSERVM
AVGVSTÆ VIND. II. VIRVM
Perſcripta. Interiectis obſeruationum delineationibus.

AVGVSTAE VINDELICORVM
Ad inſigne pinus.

Anno M. DC. XII. Idib. Septembr.

Reduced fac-simile, title page of *Accuratior Disquisitio.*

PLATE XV.

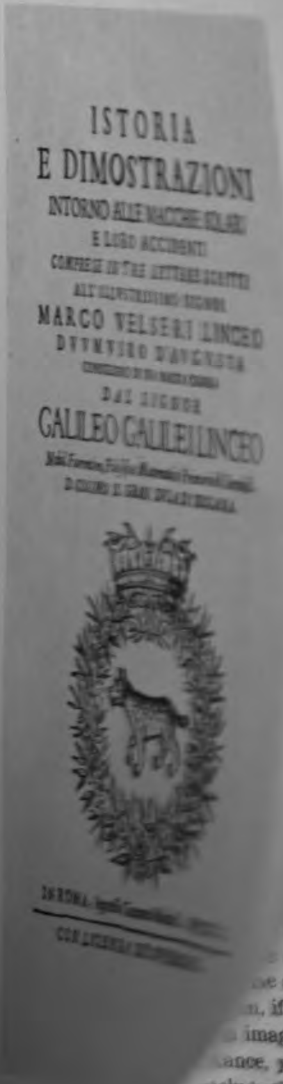


ISTORIA
E DIMOSTRAZIONI
INTORNO ALLE MACCHIE SOLARI
E LORO ACCIDENTI
COMPRESE IN TRE LETTERE SCRITTE
ALL'ILLVSTRISSIMO SIGNOR
MARCO VELSERI LINCEO
DVVMVIRO D'AVGVSTA
CONSIGLIERO DI SVA MAESTA CESAREA
DAL SIGNOR
GALILEO GALILEI LINCEO
Nobil Fiorentino, Filoſofo, e Matematico Primario del Sereniſs.
D. COSIMO II. GRAN DVCA DI TOSCANA.

IN ROMA, Appreſſo Giacomo Maſcardi. MDCXIII.
CON LICENZA DE' SVPERIORI.

Reduced fac-simile, title page of *Istoria e Dimonstrazioni.*

PLATE XV.


ISTORIA
E DIMOSTRAZIONI
INTORNO ALLE MACCHIE SOLARI
E LORO ACCIDENTI
COMPRESE IN TRE LETTERE SCRITTE
ALL'ILLVSTRISSIMO SIGNOR
MARCO VELSERI LINCEO
DVVMVIRO D'AVGVSTA
DAL SIGNOR
GALILEO GALILEI LINCEO
IN ROMA
CON LICENZA

Reprod

L' ILLVSTRISSIMO SIGNOR
MVIRO D'AVGVSTA......DAL
O Nobil Fiorentino, Filosofo, e
COSIMO II. GRAN DVCA DI
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IN TRE LETTERE SCRITTE ALL' ILLVSTRISSIMO SIGNOR MARCO VELSERI LINCEO DVVMVIRO D'AVGVSTA......DAL SIGNOR GALILEO GALILEI LINCEO Nobil Fiorentino, Filosofo, e Matematico Primario del Sereniss. D. COSIMO II. GRAN DVCA DI TOSCANA. IN ROMA, Apresso Giacomo Mascardi. MDCXIII. CON LICENZA DE SVPERIORI. (Plate XV) The edition was limited to 1400 copies; to half of these was added a reprint of the *Tres Epistolae*, and the *Accuratior Disquisitio* of Scheiner.

At this point it will be of interest to consider the various methods of observing the sun and its spots used by Galileo and Scheiner at this time, as related in their letters.

Scheiner describes the methods of observing employed by him at the close of the first letter to Welser, as follows: *

> 1. The sun may be looked at with impunity in the morning and the evening, when it is clear and not cloudy, it being within a quarter of an hour of the horizon, with an unprotected tube [telescope], but indeed it must be a good one. 2. The sun in any position whatsoever, covered by a fog or a cloud that is fairly transparent, can be seen with a naked tube, without injury to the eyes. 3. The sun, unclouded, in any position whatsoever, can be observed through a tube provided at the place where the eye is applied with a blue or green glass of sufficient thickness, plane on each side, in addition to the concave and convex glasses. This blue or green glass keeps the eye uninjured even at midday; and it is even better, if in addition to the blue glass, if it is not sufficiently thick, there be present in the air a thin cloud of fog covering the sun like a veil. 4. Observations of the sun should commence at the edge, and gradually approach the center, and then pause a moment, for the surrounding brilliancy is too great to at once permit a view of the spots.

From these instructions, it is learned that at an early date Scheiner used and recommended colored glasses. We are informed later in the *Rosa Ursina* that this was suggested to him by his pupil J. B. Cysat.

Scheiner described other methods of observing in the *Accuratior Disquisitio*: †

> The sun, admitted through a round opening, about this size —O— or a little larger, perpendicularly upon a clean white paper or other white surface, shows both itself and all bodies under it, in the same proportions as to distance and situation and number as they are in the sun itself; and in this way I have made a large number of observations......Again, if you turn a polished mirror (speculam tersum) towards the sun and reflect an image of the sun with the mirror upon a clean paper and a wall at the proper distance, you will see the spots of the sun in number, order, and size, proportionately to the size of the image, as they are in the sun. This method of observing, for which I had sought a long time in vain, I learned from a a very good friend of mine. ‡

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* *Gal. Op.* **5**, 27.

† *Gal. Op.* **5**, 61.

‡ Cysat, most probably.

The last two methods of observing were used by Scheiner as good arguments against those who believed that the spots were due to the telescope itself.

Galileo was of course acquainted with the method of projecting an image with a small aperture, although it is doubtful if he made great use of it. He mentions it in his second letter to Welser:*

> You, seeing in church the light of the sun coming through broken and distant glass, where it falls upon the pavement, place there a sufficiently large piece of white paper, and on it you will see the spots.

The method of observing by projection with the telescope, if we can believe the evidence of Micanzio's letter of September 27, 1631, was first used by Galileo. In the second letter to Welser, Galileo informs us that this method of observing was invented or discovered (ritrovato) by his pupil Benedetto Castelli. There is no mention of the time or place where Castelli communicated this method to his master, but we do know that Castelli was a pupil at Padua.† Galileo's description of the method and the instructions that he gives in the letter to Welser are so explicit and comprehensive that they are well worth quoting, and may indeed serve as a model of clearness and precision which might profitably be emulated by some of our present day writers. He writes to Welser:‡

> I am going to satisfy the promise made to Apelles, namely, as to the method of sketching the spots with great accuracy, invented as I have indicated to him in another letter by a pupil of mine named D. Benedetto Castelli, a member of a noble family of Brescia......And the method is this. The telescope must be turned toward the sun as if one wished to look at it, and after it has been adjusted and made fast, let him expose a flat white card in front of the concave glass, four or five hand-breadths distant from that glass, so that upon this card will fall the circular image of the disk of the sun, with all the spots that are found upon it, arranged and placed with exactly the same symmetry with which they are situated on the sun. And the more distant the card is from the tube, so much larger will be the said image, and the spots will be represented so much the better; and without any errors all will be seen, except many little ones which could hardly be seen even by looking through the tube with great fatigue and danger to the sight. In order to draw them correctly I first describe a circle of suitable size on the card, and then varying the distance of the card from the tube, I find the exact position of the card at which the image of the sun enlarges itself to the size of the drawn circle, which also serves as a guide and standard for keeping the plane of the card true and not inclined to the luminous cone of rays which comes from the telescope: because when it is inclined the section becomes oval and not circular, therefore it does not adjust itself to the circle drawn upon the card, but inclining the card more or less

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* *Gal. Op.* **5**, 137.

† Antonio Favaro, *Galileo Galilei e lo Studio di Padova.* Firenze, 1883. **1**, 192; **2**, 382.

‡ *Gal. Op.* **5**, 136.

> one easily finds the exact position at which the image of the sun coincides with the drawn circle. When this position has been found, one marks with a pen on the images of the spots themselves, their shapes, sizes, and positions. But it is necessary to proceed skillfully, following the movement of the sun, and frequently moving the telescope, it is necessary to try to keep it well directed toward the sun. This can be determined by looking into the concave glass in which a small luminous circle is seen, concentric with that glass when the telescope is accurately directed toward the sun. And in order to see the spots very clearly and distinctly, it is well to darken the room, closing every window so that no light may enter other than that which comes through the tube, or at least let it be darkened as much as can be, and then let there be placed on the tube a sufficiently large card-board, which will cast a shadow upon the card where one is to draw and which will prevent any light from falling on it other than that which comes through the glasses of the tube. Then it must be noted that the spots come from the tube inverted, in the reverse order to that in which they are in the sun; that is, the right becomes the left, and the upper becomes the lower, because the rays cross each other inside the tube before they pass out from the concave glass. But since we draw them on a surface facing the sun, and then turning toward the sun we should hold the card with the drawing [side] in front of our eyes, thus the surface upon which we first drew is no longer facing the sun but turned away from it, and therefore the right side again corresponds to the right side of the sun, and the left side to the left, whence it remains that only the upper and lower parts are inverted, but turning the card over and causing the upper side to become the lower and looking through the transparency of the card (the drawing being on this side away from the eye) at the light, the spots are seen correctly, just as if we were looking directly at the sun, and in this way they should be exhibited and drawn upon another card in order to have them well situated.

The letter of Fulgenzio Micanzio, previously referred to, is the evidence which leads us to believe that this method of observing was known to Galileo when at Padua. Micanzio writes from Venice:*

> I remember most distinctly that when you had made here the first telescope one of the things that you observed were the spots on the sun. And I could name the place and the point, where on a white card you showed them with your telescope.....

There will be a little question of the method of observing indicated by the wording of this letter, but whether it can be considered as a true account of what actually took place is a different matter, and one which is obviously of high importance. Arago objects† to the evidence of this letter on the ground that if the image had been produced by the object glass alone it would have been too small to show any ordinary spots. If the method described is understood to be that in which both the object glass and the eyepiece were used, Arago demands why Galileo should subsequently state that the method was shown to him by Castelli. In view of what has been quoted above, the objections of

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* *Gal. Op.* **14**, 298.

† *Oeuvres* **3**, 275.

Arago are obviously without point. Similarly Wolf[*] takes the view that the image was projected without the eyepiece.

Neither Carrara nor Favaro are inclined to give great credence to Micanzio's letter in regard to the method of observation. But mere doubt, without some tangible evidence for doubting, is not an argument against Micanzio's veracity any more on this than on the greater question of whether the spots were seen at Padua at all. Practically all competent authorities credit Micanzio's letter in this regard, and it seems hardly just to credit what is implied by the letter as a whole, only to reject a portion of it when there is no real reason for the rejection. The only real evidence for doubt, and this is by no means conclusive, is given by the letter of Maelcote to Kepler, dated December 11, 1612, which has already been quoted (page 88). In this letter Maelcote remarks that although Galileo had shown the spots to him at Rome, he neglected to observe them, fearing injury to his eyes, until he had modified Kepler's device by, "passing the rays through a dioptric tube provided with both its concave and convex glasses and properly extended." Unless Maelcote's memory was bad, which seems hardly probable, this letter indicates that when Galileo showed the spots to him in Rome he used some method of observation other than projection through the telescope. Hence it might be assumed that at this time Galileo was ignorant of the method. But the evidence is not conclusive, for we are not told what method of observing Galileo did use, nor are we told the time of day when the observations were made, which would make considerable difference. Remembering that this method was invented by Castelli, and that Castelli was a pupil at Padua, it is reasonable to suppose that Micanzio's letter is a statement of the actual facts, and that Galileo was acquainted with and employed this method at an early date.

It appears that Scheiner had at first no knowledge of the method, for he makes no mention of it previous to the date of Galileo's letter in which it is described; and hence we are led to believe that Scheiner first learned of it from this letter. Schreiber[†] on the contrary asserts that Scheiner was without doubt the first to use it, although Kepler may have been the originator. In the *Dioptrice*, Props. 88 and 105,[‡] Kepler discusses on theoretical grounds the possibility of projecting the image of an object upon paper by means of two lenses. Scheiner did not have quite the presumption to claim to be the originator of the method, nor is he generous enough to acknowledge who did originate it. In the *Rosa Ursina* he writes:[¶]

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[*] *Handbuch der Astronomie. Zürich* 1890. **1**, 567.

[†] *Op. Cit.* p. 12.

[‡] Kepler, *Opera Omnia* **2**, 550; 555.

[¶] Lib. II, p. 75.

> This simple method seems to have been invented simultaneously by learned men in different countries who were occupied with this thing [solar observation].... For I used it a long time before Galileo communicated it to Welser, having learned of it through assiduous and diligent investigation of the sun.

Schreiber gives credence to Scheiner's assertion that he had invented the method independently, even if he was in possession of Kepler's *Dioptrice* at the time; for the two propositions in question could easily have been overlooked. Rather curiously it appears from the undated letter to Wackher[*] that Kepler had no recollection of his own description of it. Apparently Kepler first learned of the method from Maelcote's letter of December 11th; Maelcote's reference to the method of "passing the rays through a dioptric tube" referring to the propositions in the *Dioptrice*. In his reply Kepler[†] states that he tired himself in vain because he had removed the eye lens, and only perceived the spots when both lenses were in place and slightly separated.

THE QUARREL BETWEEN SCHEINER AND GALILEO.

At about the time of the publication of the *Istoria* there began to be heard the premonitory rumblings which were the first indications of the bitter quarrel which was to follow between Scheiner and Galileo. It seems that the quarrel arose from a statement by Galileo in his *Il Saggiatore*[‡] denouncing Scheiner for claiming priority for the discovery of the spots, which claim Galileo believed Scheiner had no grounds for making. The quarrel soon went beyond the mere question of priority of discovery, so that eventually not only the subject of the spots with their motions and nature, but practically the whole theory of the universe became involved in the discussion. Scheiner replied in his *Rosa Ursina* with a fierce attack on Galileo. No direct answer to this was made, but in the *Dialogues on the Two Chief Systems of the World* published two years later, the *Rosa Ursina* and the theories contained therein received some rather hard knocks. Many disgraceful personalities were exchanged by the principals and their adherents, which later proved very costly to Galileo. Scheiner became one of the foremost and most relentless of his enemies, and if not actually the leader in the crusade following the publication of the *Dialogues*, did all in his power to further the persecution of the Church, which later hounded Galileo to his grave.

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[*] Kepler, *Opera Omnia*, **2**, 777.

[†] *Gal. Op.* **11**, 537.

[‡] *Il Saggiatore nel quale con bilancia esquisita e giusta si ponderano le cose contenute nella Libra astronomica a filosofica di Lotario Sarsi Sigensano, ecc.* Roma, 1623.

The attempt will be made to throw some light upon the history of this quarrel, and to show upon whom the blame for it should fall. von Braunmühl and Carrara consider Galileo the guilty party, while Scheiner is held up to view as a much abused and innocent man. The Jesuits, naturally, have always rallied to the defense of the former member of their society, and have endeavored to show how unjust and unwarranted was the attack on Scheiner in the *Saggiatore*. von Braunmühl asserts that Scheiner made no attempts to claim priority, but only defended himself from the unwarranted attacks of Galileo. In this von Braunmühl is supported by Carrara. It is somewhat difficult to state with certainty just whether Scheiner did claim priority at this time or not. The statement in the letter of January 16th, concerning his fears has been quoted (page 217). Whether Scheiner at this time knew of Galileo's discovery of the spots may be open to doubt, but as will be shown later, it is very probable that Scheiner did know of the discovery, even before he wrote the first letter to Welser on November 12th. We recall Scheiner's anxiety to have the letter speedily published in order that the credit for discovery might not be "snatched from his hands." Other than this, there is no statement in Scheiner's writings at this time which can be construed as a direct claim for the discovery, but there is other evidence from which one can judge of his pretentions in the matter. This evidence will now be given, and the reader left to judge of its validity.

Mark Welser, the intimate friend of Scheiner writes to Johann Faber, Chancellor of the Accademia dei Lincei, March 16, 1612:*

> I do not know what Galileo thinks of the solar spots, because I never had a reply......I do not believe that he can contradict the fact, but perhaps he will lament it, that, having been the first to observe these spots many weeks before, another claims the glory of it for himself; which moreover has nothing to do with the matter. And moreover I can affirm that my friend who calls himself Apelles knew nothing of the observations of Galileo, nor need it be considered a strange thing that in nature there be found various discoverers without one having the knowledge of the other. Moreover, if I am not deceived in my opinion of Apelles' modesty, I believe that he will readily yield this honor to anyone if proofs are adduced.

Ludovico da Cigoli writes to Galileo from Rome, October 19, 1612:†

> I was at the Marchesi's [Prince Cesi] who tells me that he was expecting letters from you, but despairs, and tomorrow which is Saturday he will again have them looked for at all the posts. But if there is no answer, resolve quickly, because all our friends judge it well that these letters [on the solar spots] should appear. Indeed it would have been better if you had done it when you were here, that is, spoken of the spots, so that this unknown Apelles might not have had a chance

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* *Gal. Op.* **11**, 281.

† *Gal. Op.* **11**, 418.

> to clothe (vestirsene) himself with it, as every one can see that he is trying to do......And by many signs and ways of speaking, particularly at the end, it seems to me that he is a Jesuit [!], besides which Father Gambergier [Grienberger] defends and holds the opinion that they are stars.

Giuseppe Biancani, also a Jesuit, writes to Gio. Antonio Magini, May 17, 1613:*

> As to the work of Galileo, I am glad that it has come to light. If he is not very careful in claiming this beautiful discovery of the solar spots he may be confuted by P. Christoforo Scheiner, because there are some of his [Scheiner's] manuscripts in the hands of many people, myself among others, which were spread abroad before he [Galileo] had printed those letters, and in which the first origin is seen.

In commenting on a statement in a book on optics by Father Aguillon published at Antwerp in 1613,† Prince Cesi writes to Galileo:‡

> I certainly do not know to what extent this Apelles has become known and I wonder that the Fathers insist on giving him the priority in this observation, for they know how much earlier you showed and treated of it.

But of the modesty of Apelles, concerning which Welser writes so optimistically, there is no evidence. On the contrary, for we learn from a letter by Apelles himself to Antonio Magini that he evidently never had any intention of yielding the discovery. The letter is dated January 6, 1613; he writes:¶

> Therefore I give you immortal thanks for such impartial judgment, with which you have so often defended with such great protection, my discoveries of the solar spots. I am unable to repay, except that I should show myself to you always mindful of your kindness, and that I should resort to you and that I should frequently confide myself and our Society to a name of such great authority.

Carrara asserts ‖ that previous to the publication of the *Saggiatore* there had been no question nor quarrel over the priority of discovery, nor had Scheiner expressed explicitly any claim for precedence over others, either as to observations or writings. The arguments of Carrara which purport to uphold this are stated in a manner that is neither clear nor convincing. The assertion is also made that the statements in the writings of the friends and co-religioners of Scheiner were made without his sanction or knowledge, and hence he should not be held responsible for them. This may be quite correct, but there must have been some reasons to cause Scheiner's friends to write in the way that they did.

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[*] *Gal. Op.* **11**, 509.

[†] Francisci Aguilloni, e Societ Iesu, *Opticorum libri sex, philosophis ac mathematicis utiles*. Antverpiae, 1613.

[‡] *Gal. Op.* **12**, 29.

[¶] *Gal. Op.* **11**, 461.

[‖] *Op. Cit.* 270.

If Welser, Cigoli, and others had cause to believe that Scheiner was making claims for priority, and from the quotations just given it evidently seems that they did, it is not unreasonable to suppose that Galileo also believed this for the same reasons, and the denunciation of Scheiner was not so very unwarranted after all. Just what these reasons were, outside of the statement in the letter of January 16th, and the remarks of his friends, is unknown; it may have been wholly due to the efforts of Scheiner's overzealous friends. At any rate it is certain that Scheiner did not see fit to reprove his friends for their remarks concerning him as the first observer of the spots.

It will be of interest to trace briefly the course of events which led up to Galileo's publication of his *Il Saggiatore*. While up to this time it may be that Scheiner made no direct claims for priority of discovery, his friends had certainly done so for him. Not only had the question of the discovery and nature of the spots been brought up, but every one of Galileo's other discoveries had been attacked or impugned in some manner or other. The new star of 1604, the satellites of Jupiter, the mountains of the moon, the mechanics of floating bodies, the phases of Venus with the deduction therefrom supporting the Copernican theory, all these and others, each in turn, had been attacked with extraordinary venom and malice. In particular, the doctrine of the motion of the earth in accordance with the Copernican theory, which was upheld in the letters on the Solar Spots was especially obnoxions. The uncompromising boldness with which Galileo published and supported his opinions raised against him a host of enemies. The Aristotelian professors, the Jesuits, and the timid but respectable persons who at all times dread innovations, whether in religion or in science, all began to draw together for the common defense against this philosophical tyrant who threatened them with the dangers of too much knowledge. No longer able to combat Galileo's hard facts and powerful arguments with metaphysics and the assertions that the facts were "faults" in his devilishly designed instruments, and that his arguments were vain glorious and "scientifically" absurd, his opponents went back to the fifth Century arguments, and taking their stand on theology, raised the cry that the Church was in danger. On the ground that these astronomical teachings were incompatible with Scripture, a great din was raised; and the controversy as to the relative validity in scientific matters, of observation and reasoning on the one hand, and the authority of the Church with the interpretations of Scripture on the other, was thus commenced. A controversy which, although the battle-field has shifted from one science to another, has continued almost to the present day; and which eventually proved to be the undoing of Galileo.

In 1615 Galileo went to Rome in order better to combat the intrigues against him, which had now grown to formidable proportions, but obtained small satisfaction. Early in the next year he was summoned before Cardinal Bellarmine, and on the authority of the Holy Office (The Inquisition) admonished no longer to teach nor defend the "false and philosophically absurd, and formally heretical" doctrine that the sun and not the earth was the center of the world;* which doctrine had been upheld in the *Istoria* and other publications.

In the year 1618, three comets appeared, Galileo, as was customary, published his views concerning these objects through the medium of Guiducci, a Florentine disciple.† In this essay the opinions of the Jesuit Orazio Grassi were so indiscreetly attacked as to further arouse the ire of the whole Jesuit College at Rome. Grassi in reply published a pamphlet under the name of Lotario Sarsi,‡ which in turn was an onslaught on Galileo's theory of comets, and was full of abuse of Galileo and his school.

By this time, as may be easily surmised, Galileo had pretty well succeeded in attracting to himself the enmity and hatred of a large number of the Churchmen, and others in Italy and elsewhere. Their attacks, open, and veiled, as they more frequently were, were naturally a severe trial and most annoying to Galileo. To these must be added the admonition of Bellarmine, and the claims of Scheiner and his friends for the discovery and correct theory of the solar spots.

Whatever attempts were made by Scheiner and his friends to secure the discovery of the spots were little to the liking of Galilo; nor was he better pleased with the attack of Grassi in his pamphlet on the comets. As a general remonstrance and defense against all these persecutions and attacks, Galileo wrote and published his *Il Saggiatore*. This piece of brilliant sarcastic writing was directed primarily against Grassi and his supporters. It is a masterpiece of ingenuity and skill, for the author not only dexterously avoids the snares laid for him, but brings defeat and ridicule upon his opponents at every turn. The *Saggiatore* was dedicated to Pope Urban VIII, formerly Cardinal Barberini, who later figured so prominently in the trial of Galileo.

In the *Saggiatore* Galileo laments that in general his discoveries have been impunged and the reasonings thereon made a contention from all sides. In particular he mentions the letters on the Solar Spots, for the defense of the Copernican System mentioned in these had resulted in the admonition of 1616, and writes:¶

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* Fahie, *Galileo,—his Life and Work.* p. 163.

† *Discorso della Comete di Mario Guiducci*, Firenze, 1619. *Gal. Op.* **6**, 39.

‡ *Libra Astronomica ac Philosophica.* Perusiae, 1619. *Gal. Op.* **6**, 111.

¶ *Gal. Op.* **6**, 214.

> The letters on the solar spots, by how many people and in how many ways were they opposed. And this material, which offers such a field for the development of our intellect in wonderful speculations [the motion of the earth around the sun], was either not believed by many, or was regarded as not worthy of consideration, yes, even despised and laughed at. But by others who did not wish to agree with my views, there have been brought up against me ridiculous and impossible opinions, and one in particular who was subdued and convinced by my arguments has tried to despoil me of that glory, but it belongs to me, and pretending not to have seen my writings he attempted afterwards to claim for himself the original discovery of such great wonders.

This was the attack on Scheiner which has been considered so unwarranted and unreasonable. It was perhaps uncalled for, and unnecessarily severe, particularly in the accusation of plagiarism. But recalling what has preceded, the claims of Scheiner's friends, the attacks of the Jesuits, and the other persecutions which Galileo had continually to contend against, it certainly does not seem sufficiently severe to have merited the hatred and animosity which Scheiner displayed toward Galileo during the remainder of his life.

On Scheïner's arrival in Italy in 1624, inquiring what novelties there were in mathematical works, he was presented with a copy of the *Saggiatore*. Concerning the impression made by the passage quoted above, he writes in the *Rosa Ursina*:*

> I frankly acknowledge that I at first thought that someone else and not Apelles had been attacked by the Italian Accuser [Galileo]. Nor did I know that that author had ever been injured by Apelles in any writing, or word, or deed, or sign, as he insists with such unreasonable incrimination. But I know the falsehoods spread about by some in regard to the solar spots; moreover I had seen long before, and had read the Mundus Jovialis of Simon Mayr, so I thought that these invectives were hurled by this Symbolist against him. But after I saw Mayr named and punished as would be expected, not on account of these [the spots] but on account of other crimes against the author [the supposed plagiarism of Jupiter's satellites], I have seen a quarrel started against the very contents of the Apelles letters. This one finding particular fault because he [Apelles] had taken for himself the glory of the first discovery of the solar spots, a glory which the Accuser asserts belongs to himself. Since these, and other remarks will not fit others, and since besides Apelles no other discoverer of the solar spots appears,† who will furnish a target for the Accuser, the glory of which he proclaims to be his by profession or possession, hence scarcely any doubt remains but that the last sentences in the complaint, which I shall only mention, are directed against Apelles.

And thus the quarrel commenced. Scheiner based his claims for priority on the published observations. He doubts Galileo's statements concerning the observations at Padua, for the first actual observations given by Galileo are dated April 5, 1612, while Scheiner's first authentic observations are dated October 21, 1611. Scheiner also objects to Galileo's priority because there was no announcement of the discovery, whereas all Galileo's previous discoveries had been announced in an anagram, etc. But all this has already been discussed in detail.

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* Lib. I, p. 2.

† This assertion convinces Carrara that Scheiner was ignorant of both the discovery and writing of Fabricius. But it is to be remembered that the *Mundus Jovialis* which Scheiner has just stated to have read contains the statement. "The first discoverers and observers of the solar spots are the two Fabricii, father and son." Evidently Scheiner had a bad memory.

(To be continued.)

THE SPIRAL NEBULAE.

JOHN MILLIS.

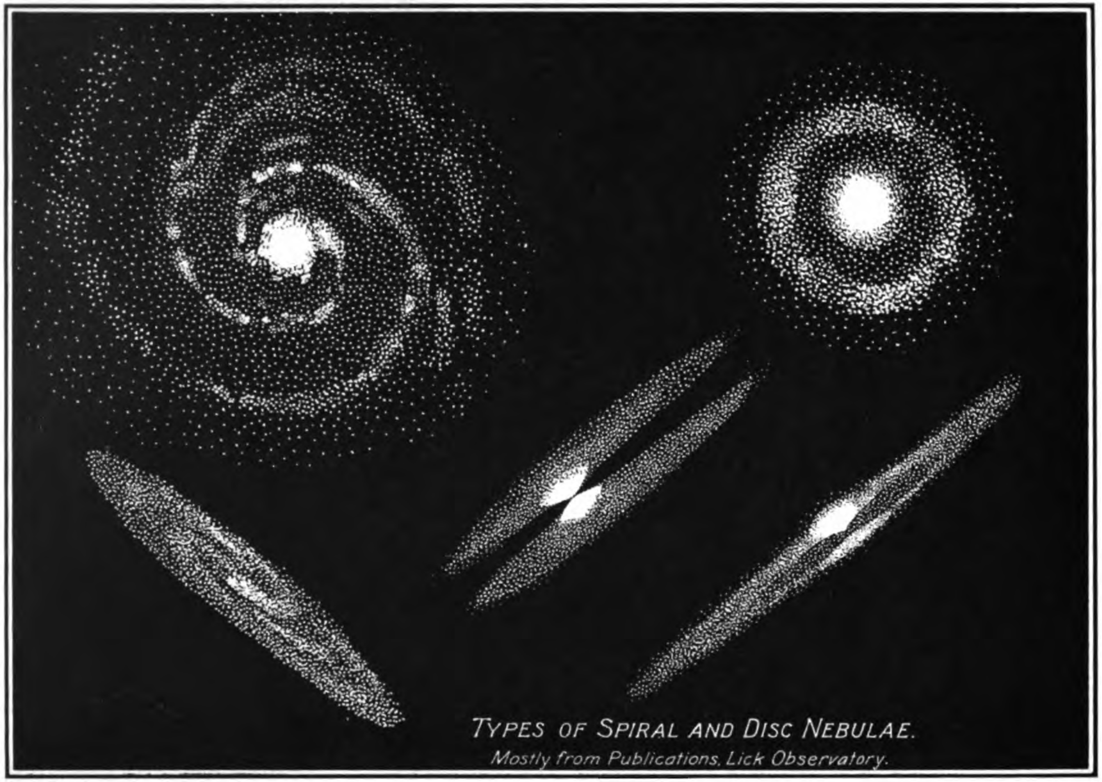
No one of those developments of recent astronomical research that have been effected by the application of advanced photographic appliances and processes to the study of the heavens is more wonderful and mysterious than the great number of nebulae that have been disclosed and the revelations regarding the forms and structure of these strange bodies that the photographic plates present. This applies especially to the discovery made in recent years that a very large majority of these remote and ghostly aggregations of matter in space exhibit certain general features of form that are common to all. The greater portion undoubtedly approximate to a more or less well-defined flattened circular or disc-like shape in general outline and their internal structure is such as to give an appearance of a flat spiral, the twist being about an axis perpendicular to the nebular disc. Many nebulae that do not decidedly show the spiral characteristics nevertheless exhibit certain quite well defined approximations or tendencies to such a structure, while the general disc-like form is so common as to make the departures from it seem exceptional. Starting from the few observed examples of nebulae that could be made out with the earlier telescopes by direct vision, the number has increased with improvements in the methods and instruments for observation until at present it is estimated that the total number within range of available means of detection must now be reckoned in the millions, or at least as over one million. The inference with respect to the prevalence of the nebulae throughout the entire material universe is obvious, and we cannot escape from a profound sense of conviction that there must be something deeply and fundamentally significant in these forms.

Naturally there has been much speculation on this subject. The theories that have been enunciated heretofore to account for these spiral and disc-shaped nebular forms differ in various details, but those that seem to have been regarded as having the largest measure of plausibility attribute the cause to the close approach, to the grazing, or to the eccentric or tangential contact of two bodies in space, with a resulting disassociation of the matter and the formation of a nebular whirl in a plane that contains the paths which the two bodies concerned were pursuing before the collision, or before the action which resulted in the formation of a nebula took place. There are grounds for regarding this idea as radically inadequate and untenable. Whatever plausibility it may have for certain special and well defined forms of the spirals, great difficulties are found in trying to make it fit the generality of the shapes that the photographic plates show, including the apparently abnormal or irregular and erratic forms. A theory to be admissible must account for the freaks as well as the "regular" spirals. Possibly the correct explanation is one of surprising simplicity.

When a lead bullet fired from a rifle strikes a flat iron target squarely, it "spatters" laterally in various directions, mostly at right angles to the direction of the bullet's flight, or parallel to the face of the target. A small residual fragment is usually found which is of a disc-like or round button shape with ragged edges. This is the central part of the bullet which remains after the greater part of it is spattered away upon impact with the target. If two bullets of equal size and moving with equal velocities should meet squarely head-on when fired from opposite directions a similar result for each bullet would follow. Each would be in effect a fixed target for the other and all or the greater part of both bullets would be dissipated and scattered through a circular or disc-like space whose plane would be at right angles to the line which defined the paths of both bullets. With sufficiently great velocities the substance of the bullets would be "blown" into minute globules of melted metal, would be disintegrated into a mist of lead, or would even be partly or wholly vaporized. It is not practicable to conceive any conditions of collision that would result in a distribution of the resulting fragments or vapor throughout a disc-like space whose plane would be *parallel* to or would contain the paths which the colliding bodies were following before impact. So far no account is taken of any motion of rotation of either bullet about an axis within itself.

Now imagine two spherical astronomical bodies of equal size and mass colliding "in space." We need not stop to consider actual dimensions or distances or velocities, so long as the respective components of velocity are equal and the relative velocity of approach is sufficient to cause the disintegration and dissipation of the matter involved. Assume a direct head-on collision. The result would be similar to that above described and the locus of the dissipated matter would be circular and

PLATE XVI.


TYPES OF SPIRAL AND DISC NEBULAE.
Mostly from Publications, Lick Observatory.

Types of Spiral and Disc Nebulae.
Drawn by John Millis.

of a flattened disc-form;—mathematically speaking a "volume of revolution" having its axis coincident with the paths of the colliding bodies, but *not* in fact generated by any revolution of matter. The process of dissolution of the colliding bodies and of the projection of the resulting debris laterally will be progressive and of varying intensity, however sudden the action. It will be most intense at the moment of first contact when the total masses and the highest velocities of both bodies are involved. The radial distribution will, however, be uniform in all lateral directions if we assume uniformity in the composition of the colliding bodies throughout their respective masses, a square head-on collision, and no motion except that of mutual approach. This will produce nebulae of the "ring" and possibly some of those of the "planetary" types.

Now suppose that motions of revolution are involved, in one or in both of the colliding bodies, in addition to the relative motion of translation. Suppose both bodies, or one of them alone, to be revolving about some axis passing through the center of the revolving body. It is easily conceivable that this would cause a variable distribution of the fragments or debris of collision along different radii of the disc-shaped locus after the bodies had collided and while they were "grinding" up and smashing themselves and each other. The revolving body would retain a residual of revolution about some axis within itself during the process, there would be one or more radii of maximum ejectment of the debris, which would revolve about the common line along which the two were travelling at the moment of impact and in a plane at right angles to it. The distance to which the debris or litter resulting from a collision is projected will be variable as determined by the intensity of the action at any particular stage in the disintegration process and by the opposing gravity effects of the remaining masses of the two bodies at that stage. Viewing these conditions in their entirety it is not difficult to see in them a situation which might reasonably produce a more or less perfect spiral nebula, generated progressively from the extreme outer limits inward;—not necessarily a revolving mass but a *form* which may be fixed in space as a whole and which is outlined by the position of the products of the general smash-up after they have practically come to rest. The form is not in process of being wound up on a turning center, nor is it being unwound from a similar center, though its parts may have some residuals of a motion of revolution. No mere close approach and no tangential or eccentric collision or "side swipe" could produce similar results in the generality of cases.

While the foregoing contemplates in general two solid spherical bodies of uniform composition, the same general principles would apply to bodies of compound internal structure or to aggregations of matter in whatever form or state of composition. To account for the great variations in the spiral forms, as well as for the forms that are not distinctly spiral at all, we are at liberty to make almost unlimited assumptions regarding the relative masses of the colliding bodies, their relative translatory velocities, and especially as to their motions of axial revolution, including the relative directions and speeds of such revolutions and the relative positions of the axes at the time of collision.

The actual forms shown in the photographic plates present the widest field for speculation with the foregoing general assumptions in mind. There are spirals of all degrees of perfection, from the beautifully formed ones with the two arms which a prominent theory heretofore promulgated calls for easily recognizable, through many variations to crude and irregular shapes that require some imagination to be classed as spirals at all. There are nebulae which indicate that the colliding bodies may have been entirely dissipated and "blown" a long distance from the center. There are others in which a central nucleus of matter appears, suggesting portions of the original bodies that escaped entire dissipation. There are shapes that suggest two spirals superposed—one right handed, the other reversed—as though each of the colliding bodies had developed a spiral form of its own. Several of the nebulae that appear to be of the spiral or at least of the disc-like form, which are seen edgewise, show a dark central space or band that may be attributed to something like a "rebound," when the masses that formed the nebula came together.

Speculations on the "age" of the nebulae are even possible on the assumption that condensation or collection sets in after the collision and explosion. The photographs show nebulae approximating to uniformity in detail structure; others with knots and patches more or less conspicuous and well defined, suggesting that the process of condensation has begun, and others that indicate formation of some individual stars. Still more remarkable we have photographs of what are plainly concentrated groups of individual stars which show clearly a general spiral arrangement for these individuals. There are, moreover, photographs of some conspicuous nebulae that without too great a stretch of the imagination can be conceived as having been produced by the simultaneous collision of *three* or more bodies with a mutual "rebound" on quite an extraordinary scale. Lastly may be mentioned the wonderful "net-work" nebula in which can be detected a twist of another kind, like a long screw of "quick pitch." Could this have been formed by the collision of two bodies, one of which dominated in the translatory motion, with the result that both were not brought up "all standing" but that the two were carried along through space while grinding together and throwing out the debris along one or more predominant directions? If these radii of projection revolved about the path of translation, in a plane normal to it, they might have formed the screw-like shape which we see, like a pin-wheel that escapes from the nail which constitutes its restraining axis and runs wild!

This theory also suggests a possible explanation of the deeply mysterious "double star drift" that has been observed. If the star group or "universe" in which the earth is located is a spiral nebula—and the Milky Way is a plausible indication that it is—it is conceivable that this has resulted from the collision of two aggregations of matter which were both dissipated and the resulting nebular matter has now assumed the form of individual masses or collections which constitute the stellar universe now visible to us. These individual masses, now seemingly intermingled, must have belonged originally to the one or the other of the two colliding masses, and it is therefore possible that they have individual residual motions which distinguish each as belonging to one or the other of two originally separate groups, while in their present distribution throughout the sky as seen from our earth no such classification is suggested. There is even something in the positions of the outside spiral nebulae with respect to our supposed Milky Way spiral "Universe" and with respect to each other that suggests some kind of law and order in the arrangement of individual "universes."

On the scale of things we are here considering, as compared to ordinary human conceptions, a collision and "explosion" with the dissipation of the matter concerned into the nebular form may of itself involve a period of duration which we would designate as protracted, to say nothing of the time that is occupied in the condensation and collection of the scattered and vaporized matter again into planets and suns and further into a state of aggregation or concentration which may be a condition precedent to another collision with a similar mass and a repetition of the whole process; thus constituting the grand cycle of transformations which all material substance undergoes everlastingly. Not only does the process continue without any end, but *it never had any beginning*! The bearing of these ideas on quite a comprehensive generalization and simplification of our theories of cosmogony will be apparent. To put it in terms that may sound somewhat ponderous, no cosmological theory which purports to be all-inclusive can be tenable if it predicates either a primordial incipiency or an ultimate finality.

All this calls for a measure of audacity on the part of one who engages in such speculations. It is customary to stand aghast at things which are big and distances which are long and periods of time which are immense, but it is reassuring to him who ventures into these regions of thought to reflect that among real things nothing absolute in the way of dimensions is recognized by nature. It is necessary simply to adapt oneself to the "environment." It is legitimate to consider the relations and characteristics of worlds, planets, suns, and nebulae, as though they were of the dimensions of birdshot, marbles, golf balls, and toy balloons, affected by actions on a commensurate scale and which continue over periods of time of corresponding magnitudes. Exactly the same principle is applicable the other way about when we speculate on the properties and relations of molecules atoms and ions.

These reflections do, however, suggest that we need new terms in, ordinary language,—something to express conceptions like superlatively unlimited space, multiple universes, super-infinities, and transcendental eternities.

Providence, R. I.
April 15, 1916.

THE POLAR REFLECTING TELESCOPE.

An Amateur's Attempt at an Observatory that may be made comfortable in cold weather.

RUSSELL W. PORTER.

There have been several attempts at various times in the past to so arrange the optical parts of the telescope, as to provide a closed observing room maintained at a different temperature from that of the outside air, the object being to mitigate the rigors of astronomical work during the winter months. Among the many efforts to demonstrate this principle may be mentioned the Equatorial Coude at Paris, the Hartness Turret telescope at Springfield, Vermont, The Gerrish Polar instrument at Harvard, and the Sheepshanks telescope at Cambridge, England. These are all refractors.

The difficulties of the problem are great; the severe and long drawn out periods of observing in extreme low temperatures would long ago have been done away with, had the proper means been found for overcoming them. The writer retains a vivid recollection of the many hours at the eyepiece of a transit instrument, on a north polar expedition, and the damaging effects that such body exposures have on the quality of the work secured.

Were the efforts to bring about a closed and warmed observing room to need the sanction of professional astronomers they would be met in these words of Professor Turner *.

"It is specially important to those who regard astronomy as an amusement rather than as a profession that they should not be gradually weaned from it by discomforts, as is so often the case......With some device for bringing the eye end of the telescope into the comfortable study, the fascination of the work would be much more lasting...... The matter is worth the attention of amateurs." He cites the opinion of Professor Pickering who wonders why amateurs have not exerted themselves further in this direction; and the case of Director Lowey at Paris, who, with advancing years, had given over the observational work of the observatory to younger men, but that, on the completion of the Equatorial Coude, he returned to the work with renewed interest.

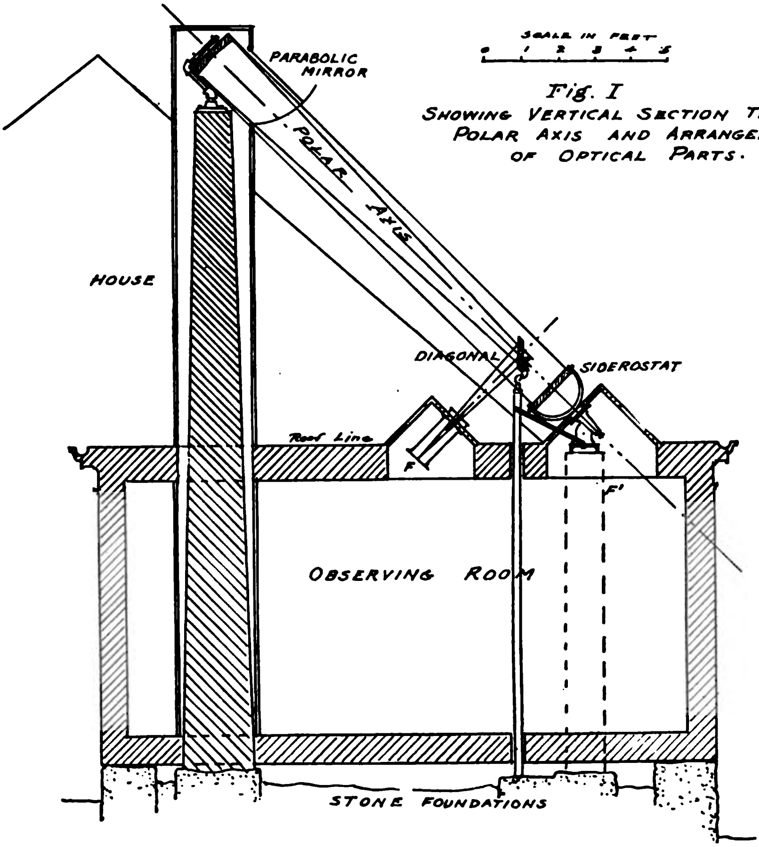


FIGURE I.

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* Modern Astronomy, (1901), p. 130-131,

It was more for the pleasure of working out the mechanical details of the problem than with any hopes of successfully solving it, that led the writer to the results which the present article is intended to describe.

As will be seen from Figure I, the arrangement involves the use of the Newtonian reflecting telescope, inverted, and rigidly fixed in the polar axis; and a siderostat in the same axis. All the optical parts (excepting the eyepiece) are outside and above the observing room, supported on piers that carry down to the ground without contact with the building.

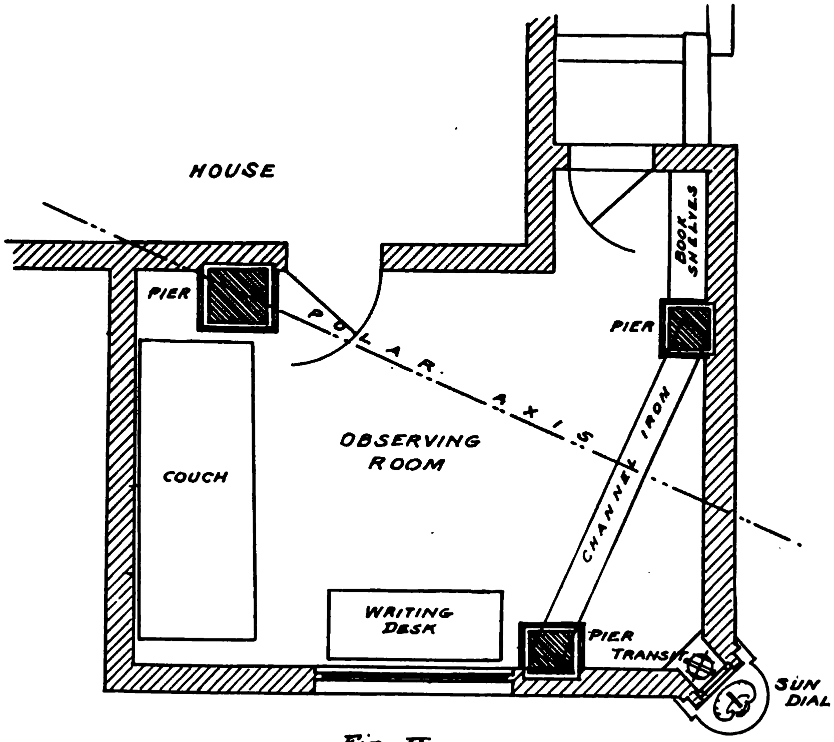

Fig. II
PLAN OF OBSERVATORY SHOWING DISPOSITION OF SUPPORTS FOR MIRRORS.
SCALE IN FEET
0 5 10

FIGURE II.

With this arrangement, all light from the siderostat reaching the parabolic mirror passes along the polar axis: it is thence returned to the diagonal mirror along the same axis, where it is again deflected through the roof to an eyepiece at the focus in the room below.

As originally designed and built, the Herschellian form was tried, and the parabolic mirror was tilted enough to return the light rays direct to a focus just below the siderostat at F′ (Figure I), thus saving the extra reflection of the diagonal.*

Sufficient astigmatism, however, developed in the image at the focus to make this form undesirable, so an alteration to the Newtonian form was made. When this change was effected, knife edge tests of the image of a star at the focus were in every way as satisfactory as the laboratory tests when the mirrors were being figured.

The observatory was built adjoining the southwest corner of the writer's home. A part of the heavens to the northeast is obscured by the house, and the immediate vicinity of the north pole is cut off by the housing of the curved mirror; but as this is the least interesting part of the heavens the loss has not been greatly felt.

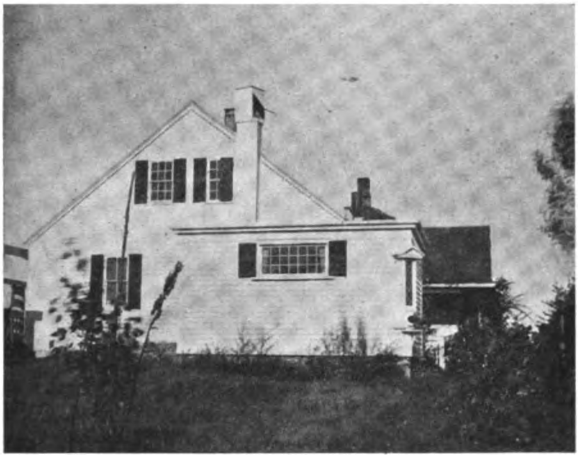

FIGURE 1.
The house and observatory from the southwest.

The siderostat is driven by a clock actuated by a weight. It is so fitted with setting circles, that an observer at the eyepiece can bring any desired part of the available heavens into his field of view. A photograph taken from below and looking up into the monitor surrounding the siderostat, shows the setting circles in right ascension and declination, and their control from the eyepiece.

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* This accounts for the siderostat being supported by the two piers carrying the channel iron, giving the necessary open space immediately below the siderostat support. With the Newtonian form this arrangement is, of course, unnecessary.

It is now in order to cast up the advantages which this very unusual form of telescope possesses, and then to enumerate its faults. It will be well to state here that some of the defects which have developed are due to imperfect mechanical details, made necessary by the writer's inability to afford costly machine work.*

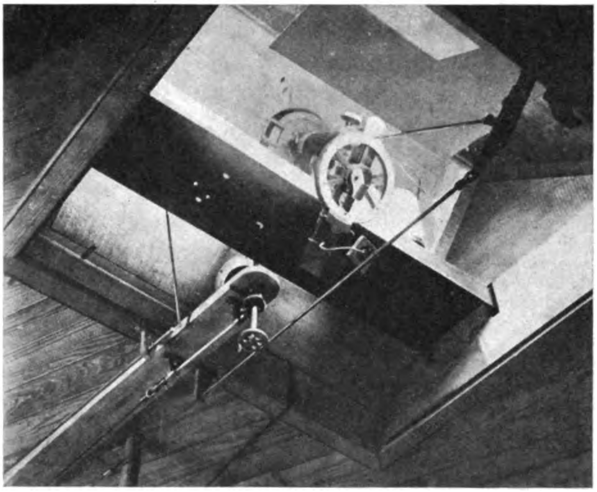

FIGURE 2.
Looking up at the ceiling of the observing room, showing the siderostat mounting, and controls from the eyepiece just outside the lower left hand corner of the photograph.

ADVANTAGES.

Unquestionably the greatest gain lies in the amateur being able to work in a closed, comfortable room, which is as much a part of the home as his den or living room. It is lighted and heated like the rest of the house. With all his books and data at his elbow he will freely consult his references whenever a question arises at the eyepiece. A couch in the corner will allow him to "make a night of it" if he chooses, without disturbing the household. The host may present to his guest the wonders of our universe with the same ease as showing him a beautiful painting in the library.

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* The cost of materials was roughly as follows:—

For the optical parts—Glass discs......	$ 40.
Abrading material	5.
Silvering	5.
For the building itself..........................	100.
Total..	150.

As all work was done by the writer at odd times, no figures for labor are available.

The other advantage lies in the convenience of a fixed eyepiece. The observer, once he has comfortably adjusted himself in the observing chair, need not alter his position. All controls are at his hand—the quick setting on any object, starting, stopping and regulating clock. The writer has found this stationary position of especial help in drawing the details of the Moon.

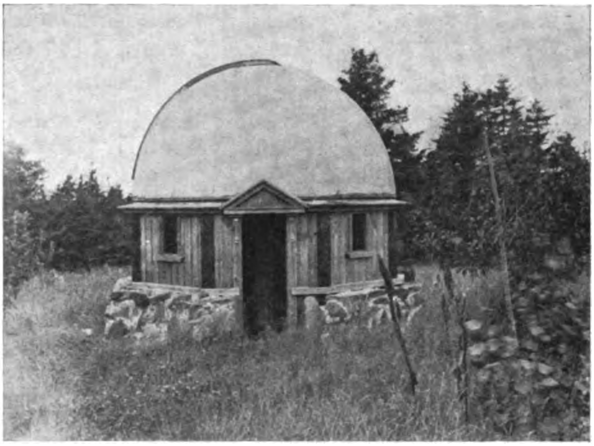

FIGURE 3.
The writer's first observatory, built by himself, to house a 6-inch equatorially mounted refractor. The dome is painted canvas on a light wood frame, and weighs but two hundred pounds.

DISADVANTAGES.

There will always with this form of telescope be a part of the northern heavens, lying behind the box covering the parabolic mirror, that will never be seen. The area is, however, small and contains none of the bodies of the solar system.

The siderostat mounting was found to be not sufficiently heavy to prevent the image vibrating when there is a strong wind. In fact, when photographing, the air must be quite calm in order to obtain negatives of good definition. The siderostat was improvised from a six-inch Mogey equatorial mounting, by removing the declination axis which carried the telescope tube, and bolting to the polar axle a yoke in which the flat swings. As a consequence the mirror, weighing some forty pounds, considerably overhangs the support of the mounting—a construction mechanically weak. A proper mounting would probably overcome this trouble, as no further noticeable tremors could be detected originating in either the parabolic mirror or diagonal.

The siderostat mirror adds one more reflecting surface to the two already found in the common reflector, a certain amount of light thereby being absorbed and lost.

Condensation on the three mirrors have on certain nights proved very troublesome, and it is difficult to see how, in this form of instrument, it could be overcome. Hot, dry cloths, held close to the silvered surfaces will remove the moisture, but only for a time.

No dimensions have yet been given. The curved mirror is 16 inches (41 cm) in diameter and has a focal length of 15½ (4.7m) feet. The siderostat is also 16 inches in diameter. Both of these mirrors are 2 inches (5 cm) thick. The diagonal mirror is an ellipse whose diameters are 10 (25 cm) and 7 (18 cm) inches. It is one inch (2.5 cm) thick. All the mirrors were ground and figured by the writer at his home on the Maine coast.*

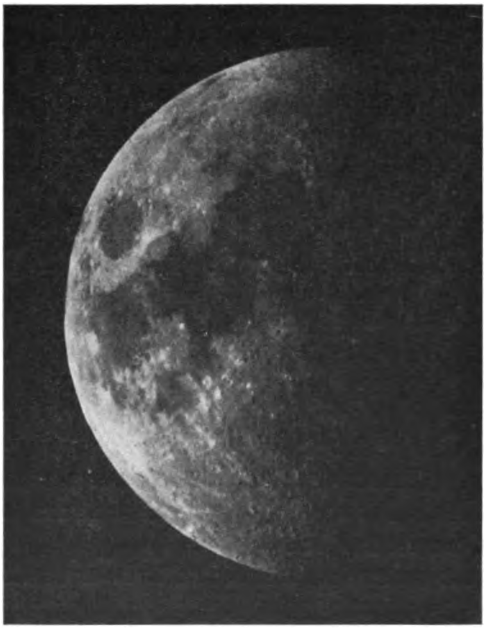

FIGURE 4.

It will thus be seen that the polar reflecting telescope, as worked out by the writer, while proving the feasibility of the warmed observing room, is still subject to the evils of condensation and wind tremors: that the latter with proper mounting can probably be removed, but the former probably cannot. On the whole, its maker was very well pleased with the results. He has had but little time as yet to give it a fair trial, and has been something over a year in making it.

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* For the benefit of those who desire to make their own reflectors, they are referred to M. Thos. Fullan, Director of Instrumental Section, Society of Practical Astronomy, Auburn, Ala., who, I am sure, will be glad to furnish simple directions for prosecuting this fascinating work.

The photograph of the moon accompanying this description was a first attempt to replace the eyepiece with the dry plate, and is probably not a fair sample of what the instrument can do. It was taken in this way.

The driving clock was disconnected from the siderostat and attached to the ceiling in the vicinity of the focus: the end of a cord wound around the clock drum shaft was then attached to the end of the plate-holder which rested in ways parallel to the apparent motion of the moon's image. The clock was then started and the plate exposed (2½ seconds). If it were desired to take long exposures, it would be necessary to rotate the plate-holder.

In closing this account the writer feels quite ready to recommend this instrument, not to professionals, but to those persons who, appreciating the wonders of the heavens, have hitherto foregone the pleasures of astronomical work from a disinclination to submit themselves to its inconveniences. The writer's experience has been this: four years ago he acquired a six-inch refractor and mounted it beneath the dome of the standard type. As a consequence, months at a stretch would pass, especially during the colder weather, without the observatory being used. It being only a hobby, he simply would not go to the trouble of bundling up, and the discomfort of standing still and shivering through the cold nights. He thus missed some of the best nights of the year for seeing. When the new observatory was completed, the exact reverse obtained. Scarcely a clear night passed that he was not at work in the room.

There is another form of reflecting telescope which it would be interesting to apply to this idea of a closed observing room—that is the Cassigranian. The arrangement is suggested in Figure III. As will be seen, all three mirrors are enclosed in the telescope tube which revolves in the polar axis. The eyepiece is just behind the parabolic mirror, in the room, at a convenient height above the floor. The flat mirror is at the opposite end of the tube in bearings at right angles to the polar axis, and a part of the tube removed to permit the maximum range in declination. The driving mechanism would be applied to the upper end of the tube, at which both controls—right ascension and declination—would be located.

Advantages of this arrangement would be—the bringing of all supports much nearer to the ground; the assembling of all optical parts in a compact unit; the convenient position of the observer when sitting at the eyepiece; and the probable reduction of troubles arising from wind tremors and condensation. Against these points in its favor must be mentioned the limited range in declination—from the southern horizon to about thirty degrees north of the zenith.

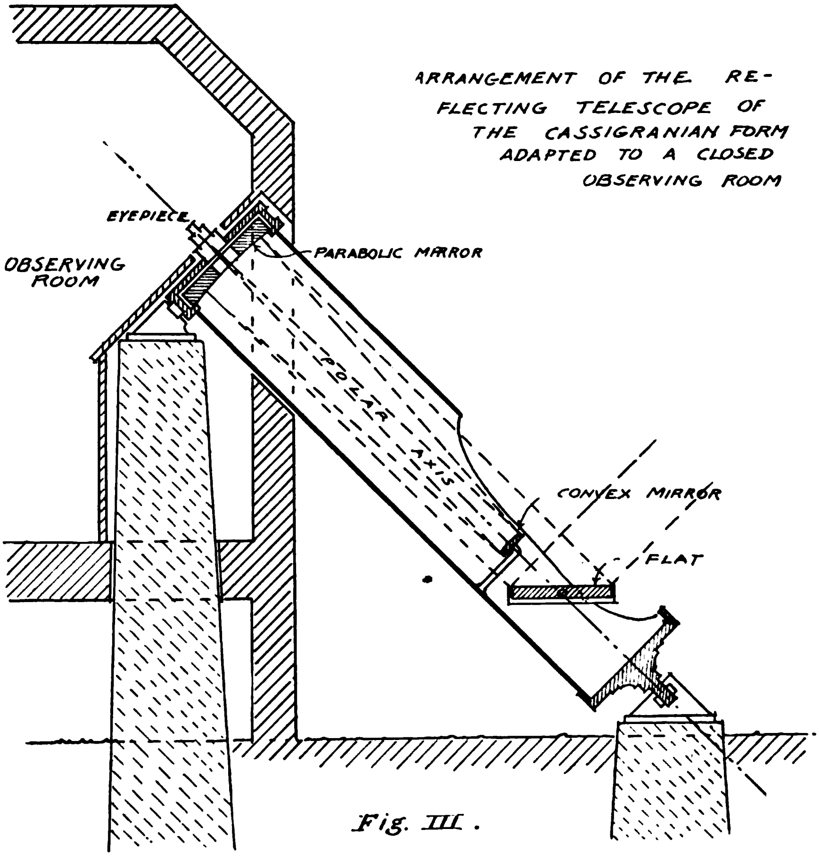

ARRANGEMENT OF THE REFLECTING TELESCOPE OF THE CASSIGRANIAN FORM ADAPTED TO A CLOSED OBSERVING ROOM
EYEPIECE
OBSERVING ROOM
PARABOLIC MIRROR
POLAR AXIS
CONVEX MIRROR
FLAT
Fig. III.

FIGURE III.

One or two other features of the observatory may be of interest. In Figure II may be seen a small corner bay window. Here is located a four inch alt-azimuth instrument. A south meridian mark, situated some two miles out in the Atlantic Ocean on the Old Scilly Ledge, serves to bring the instrument into the meridian for the purpose of obtaining correct time. Just outside of the transit window is seen the Hartness sun dial, from which, after adjustment, the mean time may be read off directly. Inside the observatory the walls are covered with maps and charts of the north polar regions where the writer has spent many years in astronomical and topographical work—Franz Josef Land, Greenland, Labrador, and Alaska.

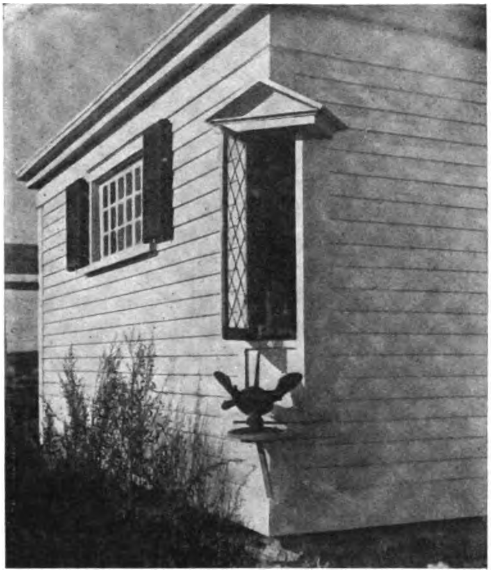


FIGURE 5.
The transit window where the sun is observed for time,
with the Hartness Sun Dial below.

The observatory is located on a point of land jutting out into the Atlantic at the small fishing town of Port Clyde, lying about one hundred and fifty miles northeast from Boston on the Maine coast.

"Land's End" Port Clyde, Maine.
December, 1915.

THE RUINED LUNAR CRATER WALLS.

JOHN A. COOK.

For more than thirty years I have been studying and observing the Lunar surface in an amateurish way, using instruments ranging in size from two to ten inches, and have arrived at conclusions at variance with those, so far as I know, held by the great selenographers living and dead regarding the above mentioned features.

We find them scattered about over the floors and shores of the Ocean and seas. When found fully down on the sea floor they often present but the merest trace of a ring. Those on the shore will show that part down in the sea destroyed, while that portion of the crater on higher ground is intact.

Writers speak of them as Ruined walls, Submerged walls, Melted walls, and often as destroyed by some unknown cause.

I have searched the works of Neison, Pickering, Elgar, Lohrmann, Fauth, Nasmyth & Carpenter, Serviss and a host of other more general works to find if some one would not suggest water erosion, and if not why not, to account for their ruined condition, but have failed. The opinion seems to prevail that they have been submerged, inundated by molten matter welling up from the interior burying them. As this would require material enough to spread over between two and three millions of square miles, and to a depth of more than a mile, and as we find no trace of such a lava outflow except in the seas, if there, I find it difficult to accept the theory, even with my great respect for the above named masters of selenography.

Some of the above named writers claim they find no trace of water ever having been on the moon, but most writers with whom I am familiar seem willing to admit that there may have been water in those old basins once.

The moon is covered with mountains, and as water enters extensively into mountain making on our planet, we may reasonably assume that it did so on our satellite, and how the moon could have left the earth, either as nebulous matter, or as a chunk out of the Pacific basin, which theory I do not think will hold water, it is impossible to understand why the elements of which water is composed did not accompany it.

Aside from theory, I think we see the evidences of the effect of water everywhere. Fill those basins with water and the tides produced by the earth would be vastly greater than any we have here on earth. Laden those waves with sand, gravel and rock, and any crater wall or other elevation that opposed them would soon be ground away, and its debris scattered about forming those long, low, winding sand ridges, seen in such numbers over the sea floor under a low sun.

Many writers speak of such formations as Fracastorius and Letronne as bays, yet in nearly every instance it is possible to trace the complete wall under oblique light. Sinus Iridium may have been a huge walled plain, or it may have been a true bay, but from the number of sand ridges in the neighborhood, it makes it easy to imagine that a wall has been disintegrated by the grit ladened waves crossing the sea of showers.

The base of the Apennines on the Imbrium side shows the effect of tidal action, and the eroded material has been deposited in the near by part of the sea, forming the shallows, shown on the maps as Palus Putredinis.

Any one studying the broad, flat floored, perpendicular walled canyons connecting Crisium and Tranquility, under proper illumination and with a power of 600 or 700, will, I think, be convinced that he sees the effect of torrential currents surging through them.

It is needless to continue this line of thought. The evidences of wave effect I think are preponderating and can be seen if looked for without prejudice. And when we admit that those basins were once filled with water, and consider the immense tides that would be produced by the earth's attraction, and that we find these ruined walls always just where the tides would have reached them, and never anywhere else, why not ascribe their ruination to water erosion?

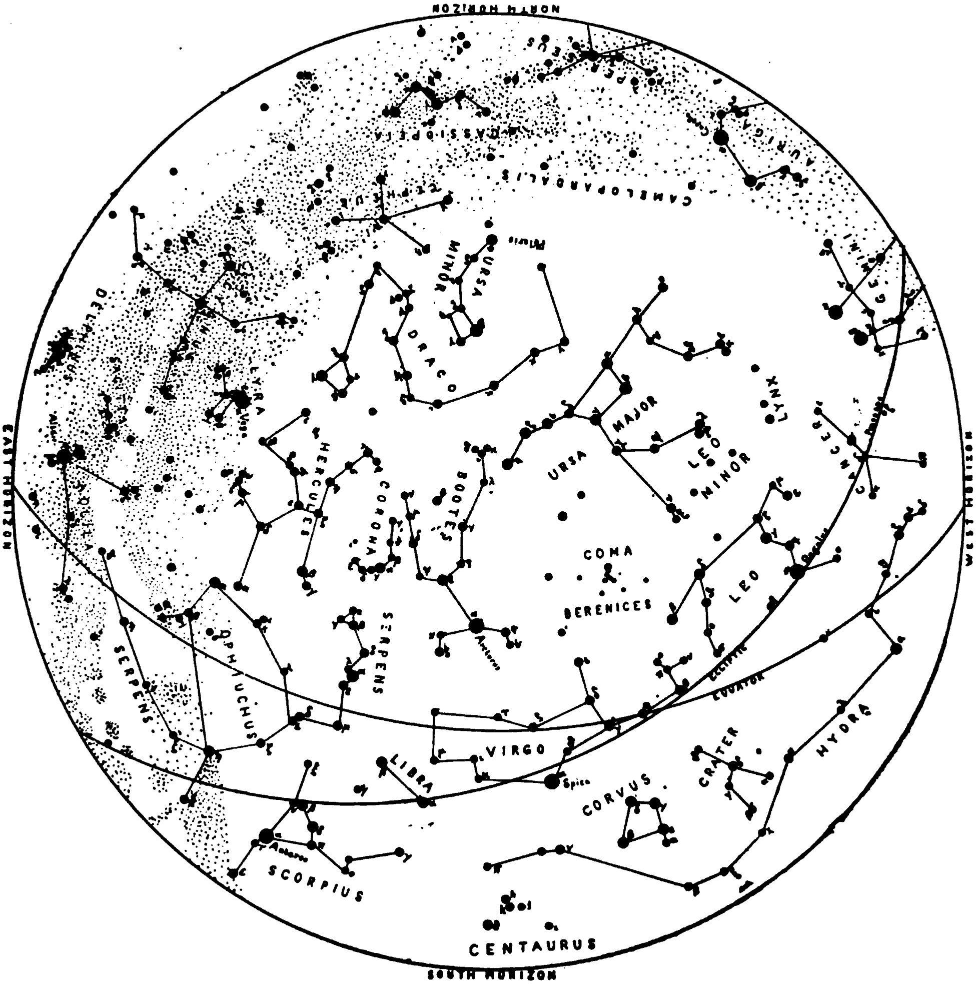
There have been countless maps and drawings made of the Lunar features, but never with the power that might now be applied. And to say that 200 or 300 will show all there is to see is a mistake. What we need is some one with the mental and instrumental equipment of Professor Percival Lowell to devote the necessary time to this work, and then give us a map and a book that will make him rich in gold and the world richer in knowledge of our satellite.

Macon, Mo.
Jan. 28, 1916.

PLANET NOTES FOR JUNE, 1916.

CLIFFORD C. CRUMP.

The sun will move eastward during the month from the constellation Taurus into Gemini. On the twenty-fifth of the month it will be in the region of μ Geminorum and at the close of the month it will be just a few degrees south and about an hour preceding Pollux. On Wednesday, June 21, the sun will reach its greatest northern declination, +23° 27′. This date is called the summer solstice.



THE CONSTELLATIONS AT 9:00 P. M. JUNE 1.

The phases of the moon for this month are as follows:

First Quarter	June 8	at	6 P.M.	C.S.T.
Full Moon	15	"	4 P.M.	"
Last Quarter	22	"	7 A.M.	"
New Moon	30	"	5 A.M.	"

The moon will be at apogee twice during the month, once on June 3, and again on June 30. It will be at perigee on June 16.

Mercury will continue its retrograde motion until June 17, it will then move eastward. It will be in a favorable position for observation on the morning of June 29, just before sunrise. It will be found in the constellation of Taurus.

Venus will continue its easterly course in the constellation of Gemini until June 12. On this date it will begin to move with a retrograde motion. At the beginning of the month it may be seen low in the western sky just after sunset. During the month it will become invisible.

Mars will move westward in the constellation Leo. It will continue to be in a favorable position for observation.

Jupiter will be seen in the morning sky in the constellation of Pisces.

Saturn will be visible in the early part of the month only.

Uranus will be found in the constellation Capricornus. It will be in position for observation.

Neptune will be approaching the sun in the constellation of Cancer. It may be seen in the western sky in the early evening.

Mars at the Opposition 1915-16.—A curious set of features, secondary to the main canal network, have become apparent on Mars. Within some of the polygons made by the intersections of the larger canals a tiny dot has been descried at this observatory, joined to a corner and to the sides of the polygon by lines so slender they usually appear as a string of minute beads. The effect is of a centrally woven web, spun within the borders of the polygon, of a more minute order of tenuity than the polygon itself. Elysium was the first example of this phenomenon with the Fons Immortalis and five connecting spokes. A second has ust been detected in eastern Arcadia, the region bounded by the Acheron, Lapadon, Clarius and Psillis; the Fons Senectutis and four spokes reproducing the same singular arrangement. These details are so minute and so curiously disposed as to suggest a new order of Martian markings.

PERCIVAL LOWELL.

Flagstaff, Arizona.
March 30, 1916

Occultations Visible at Washington.

Date 1916	Star's Name	Magnitude	IMMERSION. Washington M.T.			EMERSION. Washington M.T.			Duration	
			h	m	Angle f'm N. °	h	m	Angle f'm N. °	h	m
June 8	*p*5 Leonis	5.3	7	14	148	8	30	288	1	16
11	87 Virginis	5.8	12	18	187	12	34	213	0	16
13	*b* Scorpii	4.7	13	48	129	14	42	238	0	54
16	172 B Sagittarii	5.8	8	31	53	9	23	299	0	52
16	189 B Sagittarii	6.1	11	13	44	12	15	294	1	2
16	208 B Sagittarii	6.1	15	8	47	16	14	269	1	6
18	29 Capricorni	5.5	13	56	50	15	12	249	1	16
21	22 Piscium	5.8	14	50	132	15	5	155	0	15
22	136 B Piscium	6.5	15	47	18	16	47	270	1	0

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5ʰ; Central Standard 6ʰ; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1916 June			
	h m	° ′		d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8		27 21		
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	3 15;	11 7;	18 23;	26 15
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	1 9;	8 19;	16 6;	23 16
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	5 8;	12 19;	20 7;	27 18
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	7 17;	13 20;	19 23;	26 2
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	4 3;	11 6;	18 10;	25 13
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	2 1;	8 22;	22 16;	29 12
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	7 11;	14 15;	21 19;	28 23
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	4 9;	13 3;	21 22;	30 17
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	7 2;	15 1;	23 0;	30 22
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6		18 12		
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	4 18;	10 12;	21 23;	27 16
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	7 9;	14 4;	20 23;	27 18
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	1 16;	9 13;	17 11;	25 9
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	7 6;	15 14;	23 21	
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	6 10;	14 8;	22 5;	30 3
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	6 5;	19 10		
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	7 11;	16 22;	26 8	
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1		12 23;	25 9	
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	3 8;	10 0;	23 8;	30 0
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	4 0;	9 11;	20 8;	25 19
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	5 22;	11 22;	23 23;	30 0
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	8 14;	17 6;	25 22	
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	7 23;	18 9;	23 19	
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	3 14;	11 14;	19 14;	27 15
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	1 7;	7 1;	18 12;	29 23
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	6 10;	12 0;	23 5;	28 19
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	6 12;	14 17;	22 22	
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	5 2;	12 17;	20 8;	27 23
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	7 2;	19 7		
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	5 20;	13 0;	20 4;	27 8
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	4 16;	13 18;	22 20	
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	4 9;	13 17;	23 0	
Y Camelop.	27.6	+76 17	9.5—12	3 07.3		11 17;	21 15;	31 13
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	9 10;	17 20;	26 5	
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	6 4;	12 15;	19 1;	25 11
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	5 22;	13 5;	20 11;	27 18
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	6 15;	14 18;	22 21;	30 23
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	7 14;	17 2;	26 13	
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	4 16;	13 19;	22 22	
S Antliae	27.9	−28 11	6.7— 7.3	0 07.8	2 17;	9 4;	22 3;	28 15
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	5 0;	10 22;	22 19;	28 18
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	7 5;	15 15;	24 2	
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	3 3;	12 10;	21 16;	30 23
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	4 11;	11 2;	24 7;	30 21
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	3 14;	12 10;	21 5;	30 0
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	2 8;	9 16;	16 23;	24 7
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	7 1;	13 19;	20 14;	27 9
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	5 7;	12 19;	20 8;	27 18
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	2 3;	11 17;	21 7;	31 22

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 June							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SS Centauri	13	07.2	—63	37	8.8—10.4	2	11.5	3	5;	10	16;	18	2;	25	13
δ Librae	14	55.6	— 8	07	4.8— 6.2	2	07.9	1	1;	8	1;	22	0;	28	23
U Coronae	15	14.1	+32	01	7.6— 8.7	3	10.9	6	20;	13	17;	20	15;	27	13
TW Draconis		32.4	+64	14	7.3— 8.9	2	19.4	4	19;	13	5;	21	15;	30	1
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	2	5;	9	21;	17	13;	25	4
SW Ophiuchi	16	11.1	— 6	44	9.2—10.0	2	10.7	3	3;	10	11;	17	19;	25	3
SX Ophiuchi		12.6	— 6	25	10.5—11.2	2	01.5	4	17;	13	0;	21	6;	29	12
R Arae		31.1	—56	48	6.8— 7.9	4	10.2	1	21;	10	18;	19	14;	28	11
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1	2	8;	13	9;	23	2		
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	4	5;	11	0;	17	20;	24	15
U Ophiuchi		11.5	+ 1	19	6.0— 6.7	0	20.1	7	11;	15	20;	24	5		
u Herculis		13.6	+33	12	4.6— 5.4	2	01.2	4	23;	11	2;	23	10;	29	13
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	7	1;	14	6;	21	11;	28	16
RV Ophiuchi		29.8	+ 7	19	9. —12	3	16.5	7	0;	14	9;	21	18;	29	3
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	8	3;	16	7;	24	12		
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	5	0;	12	13;	20	1;	27	14
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	1	10;	9	3;	16	21;	24	15
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	4	23;	12	23;	20	22;	28	22
WX Sagittae		53.6	—17	24	9.2—10.8	2	03.1	5	22;	14	10;	22	22		
WY Sagittae	17	54.9	—23	1	9.5—10.6	4	16.0	6	23;	16	7;	25	15		
SX Draconis	18	03.0	+ 58	23	9.3—10.5	5	04.1	4	21;	15	5;	25	13		
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	1	11;	8	17;	23	5;	30	10
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	4	7;	11	4;	18	2;	25	0
RZ Scuti		21.1	— 9	15	7.4— 8.3	15	03.2	1	10;	16	13				
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	5	23;	14	5;	22	11;	30	18
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	7	18;	16	16;	25	13		
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	7	5;	15	13;	23	20		
RR Draconis		40.8	+62	34	9.3—13	2	19.9	3	12;	12	0;	20	12;	28	23
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	3	2;	9	17;	23	0;	29	16
β Lyrae		46.4	+33	15	3.4— 4.1	12	21.8	4	13;	17	11;	30	9		
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	4	14;	14	3;	23	17		
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	3	1;	10	15;	18	4;	25	18
RV Lyrae		12.5	+32	15	11. —12.8	3	14.4	5	17;	12	22;	20	3;	27	8
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	3	5;	12	4;	21	3;	30	2
U Sagittae		14.4	+19	26	6.5— 9.0	3	09.1	6	12;	13	6;	20	0;	26	19
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	5	3;	12	12;	19	20;	27	5
TT Lyrae		24.3	+ 41	30	9.3—11.6	5	05.8	2	19;	8	1;	18	13;	29	0
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	2	12;	9	0;	22	1;	28	14
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	3	12;	9	12;	21	12;	27	12
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	7	7;	13	22;	20	12;	27	3
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	1	9;	10	12;	19	16;	28	19
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	4	1;	12	11;	20	21;	29	8
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	5	20;	12	15;	19	10;	26	5
UW Cygni		19.6	+42	55	10.5—10.8	3	13	3	17;	10	14;	17	12;	24	10
V Vulpec.		32.3	+26	15	8.2—9.8	37	19.0	6	19						
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	4	7;	13	21;	23	12		
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	1	14;	10	18;	19	23		
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	6	13;	14	0;	21	12;	29	0
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	5	20;	11	16;	23	8;	29	5
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	9	16;	19	18;	29	21		
VV Cygni	21	02.3	+45	23	12.1—13.8	1	11.4	7	7;	14	16;	22	1;	29	11
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3			10	7;	19	23;	29	16
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	7	23;	15	20;	23	17		
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3			19	3				
RT Lacertae	21	57.4	+43	24	9.1—10.5	5	01.7	2	7;	12	10;	22	14		
RW Lacertae	22	40.6	+49	08	10.2—11.2	5	04.4	1	12;	6	18;	17	1;	27	10
X Lacertae	22	45.0	+55	54	8.2— 8.6	5	10.6	6	4;	11	14;	22	12;	27	22
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.3	8	2;	16	9;	24	16		
Y Piscium		29.3	+ 7	22	9.0—12.0	3	18.4	2	21;	10	10;	17	22;	25	11
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	5	1;	13	7;	21	12;	29	18

Maxima of Variable Stars of Short Period.

[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. June							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SX Cassiop.	0	05.5	+54	20	8.6— 9.4	36	13.7	5	6;						
SY Cassiop.	0	09.8	+57	52	9.3— 9.9	4	1.7	6	0;	14	4;	22	7;	30	10
RR Ceti	1	27.0	+ 0	50	8.3— 9.0	0	13.3	8	2;	15	20;	23	15		
RW Cassiop.	1	30.7	+57	15	8.9—11.0	14	19.2			13	22;	28	17		
V Arietis	2	09.6	+11	46	8.3— 9.0	0	23.8	5	6;	13	5;	21	3;	29	2
SU Cassiop.	2	43.0	+68	28	6.5— 7.0	1	22.8	2	16;	10	12;	18	7;	26	2
TU Persei	3	01.8	+52	49	11.4—12.2	0	14.6	3	20;	11	3;	18	9;	25	16
RW Camelop.	3	46.2	+58	21	8.2— 9.4	16	00.0			12		28			
SX Persei	4	10.2	+41	27	10.4—11.2	4	07.0	5	4;	13	18;	22	8;	30	22
SV Persei		42.8	+42	07	8.8— 9.6	11	03.1	9	17;	20	20				
RX Aurigae	4	54.5	+39	49	7.2— 8.1	11	15.0	9	11;	21	2				
SX Aurigae	5	04.6	+42	02	8.0— 8.7	1	12.8	1	5;	8	21;	16	12;	24	4
SY Aurigae		05.5	+42	41	8.4— 9.5	10	03.3	1	10;	11	13;	22	17		
Y Aurigae		21.5	+42	21	8.6— 9.6	3	20.6	1	5;	8	22;	16	15;	24	8
RZ Gemin.	5	56.6	+22	15	9.1—10.0	5	12.7	1	7;	12	8;	23	9;	28	22
RS Orionis	6	16.5	+14	44	8.2— 8.9	7	13.6	6	7;	13	21;	21	10;	29	0
T Monoc.		19.8	+ 7	08	5.7— 6.8	27	00.3			17	19				
RZ Camelop.		23.7	+67	06	11.0—13.0	0	11.5	1	23;	9	4;	23	14;	30	19
W Gemin.		29.2	+15	24	6.7— 7.5	7	22.0	1	3;	9	1;	16	23;	24	21
ζ Gemin.	6	58.2	+20	43	3.7— 4.3	10	03.7	2	19;	12	23;	23	3		
RU Camelop.	7	10.9	+69	51	8.5— 9.8	22	06.5			12	7				
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	3	15;	11	13;	19	12;	27	11
V Carinae	8	26.7	−59	47	7.4— 8.1	6	16.7	3	21;	10	14;	24	0;	30	16
T Velorum	8	34.4	−47	01	7.6— 8.5	4	15.3	1	15;	10	22;	20	4;	29	11
V Velorum	9	19.2	−55	32	7.5— 8.2	4	08.9	3	12;	12	6;	21	0;	29	18
Z Leonis	9	46.4	+27	22	7.9— 9.6	59	0.0								
RR Leonis	10	02.1	+24	29	9.1—10.1	0	10.9	5	1;	11	20;	18	15;	25	9
SU Draconis	11	32.2	+67	53	8.9— 9.6	0	15.8	2	23;	9	14;	22	19;	29	9
S Muscae	12	07.4	−69	36	6.4— 7.3	9	15.8	1	12;	11	4;	20	20;	30	12
SW Draconis		12.8	+70	04	8.8— 9.6	0	13.7	6	12;	14	12;	22	11;	30	11
T Crucis		15.9	−61	44	6.8— 7.6	6	17.6	5	0;	11	18;	18	12;	25	4
R Crucis		18.1	−61	04	6.8— 7.9	5	19.8	6	4;	12	0;	23	15;	29	11
S Crucis	12	48.4	−57	53	6.5— 7.6	4	16.6	5	14;	14	23;	24	9;	29	1
W Virginis	13	20.9	− 2	52	8.7—10.4	17	06.5			17	22				
SS Hydrae		25.0	−23	08	7.4— 8.1	8	4.8	4	14;	12	19;	21	0;	29	5
RV Urs. Maj.	13	29.4	+54	31	9.2— 9.9	0	11.2	5	20;	12	20;	19	21;	26	21
ST Virginis	14	22.5	− 0	27	10.3—11.4	0	09.9	2	0;	10	5;	18	11;	26	16
V Centauri		25.4	−56	27	6.4— 7.8	5	11.9	4	10;	9	22;	20	21;	26	9
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	5	5;	12	18;	20	7;	27	20
RU Bootis	14	41.5	+23	44	12.8—14.3	0	11.9	1	7;	8	17;	23	13;	30	23
R Triang. Austr.	15	10.8	−66	08	6.7— 7.4	3	09.3	5	18;	12	13;	19	8;	26	2
S Triang. Austr.	15	52.2	−63	29	6.4— 7.4	6	07.8	2	17;	9	1;	21	16;	28	0
S Normae	16	10.6	−57	39	6.6— 7.6	9	18.1	2	12;	12	6;	22	0		
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	6	16;	15	12;	24	9		
RV Scorpii	16	51.8	−33	27	6.7— 7.4	6	01.5	6	13;	12	15;	24	18;	30	19
X Sagittarii	17	41.3	−27	48	4.4— 5.0	7	00.3	7	1;	14	2;	21	2;	28	2
Y Ophiuchi		47.3	− 6	07	6.1— 6.5	17	02.9	6	4;	23	7				
W Sagittarii	17	58.6	−29	35	4.3— 5.1	7	14.3	8	8;	15	22;	23	12		
Y Sagittarii	18	15.5	−18	54	5.4— 6.2	5	18.6	2	13;	8	8;	19	21;	25	15
U Sagittarii		26.0	−19	12	6.5— 7.3	6	17.9	3	20;	10	14;	24	1;	30	19
Y Scuti		32.6	− 8	27	8.7— 9.2	10	08.3			10	4;	20	12;	30	20
Y Lyrae		34.2	+43	52	11.3—12.3	0	12.1	5	10;	11	11;	23	13;	29	13
RZ Lyrae	18	39.9	+32	42	9.9—11.2	0	12.3	5	22;	12	1;	24	8;	30	11

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. June							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
RT Scuti	18	44.1	−10	30	9.1— 9.7	0	11.9	3	4;	9	2;	21	0;	26	22
κ Pavonis	18	46.6	—67	22	3.8— 5.2	9	02.2	5	17;	14	20;	23	22		
U Aquilae	19	24.0	− 7	15	6.2— 6.9	7	00.6	7	6;	14	6;	21	7;	28	7
XZ Cygni		30.4	+56	10	8.6— 9.3	0	11.2	7	5;	14	5;	21	5;	28	5
U Vulpec.		32.2	+20	07	6.5— 7.6	7	23.5	8	5;	16	4;	24	4		
SU Cygni		40.8	+29	01	6.2— 7.0	3	20.3	2	6;	9	23;	17	15;	25	8
η Aquilae		47.4	+ 0	45	3.7— 4.5	7	04.2	5	10;	12	15;	19	19;	26	23
S Sagittae		51.5	+16	22	5.6— 6.4	8	09.2	6	17;	15	2;	23	11		
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	6	16:	13	0;	19	8;	25	15
X Cygni	20	39.5	+35	14	6.0— 7.0	16	09.3	6	11;	22	20				
T Vulpec.		47.2	+27	52	5.5— 6.1	4	10.5	2	17;	11	14;	20	11;	29	8
WY Cygni		52.3	+30	03	9.6—10.4	0	13.5	5	19;	12	12;	19	6;	25	23
RV Capric.		55.9	−15	37	9.2—10.1	0	10.7	4	22;	11	15;	18	8;	25	1
TX Cygni	20	56.4	+42	12	8.5— 9.7	14	17.4	3	23;	18	16				
VY Cygni	21	00.4	+39	34	8.8− 9.5	7	20.6	8	15;	16	12;	24	8		
SW Aquarii		10.2	— 0	20	9.9−10.8	0	11.0	1	2;	7	23;	21	18;	28	15
VZ Cygni	21	47.7	+42	40	8.2− 9.2	4	20.7	5	19;	15	12;	25	6;	30	3
Y Lacertae	22	05.2	+50	33	9.1− 9.6	4	07.8	9	4;	17	20;	26	11		
δ Cephei		25.5	+57	54	3.7− 4.6	5	08.8	2	22;	13	16;	24	9;	29	18
Z Lacertae		36.9	+56	18	8.2− 9.0	10	21.1	6	9;	17	6;	28	3		
RR Lacertae		37.5	+ 55	55	8.5− 9.2	6	10.1	5	17;	12	3;	18	13;	25	0
V Lacertae	22	44.5	+55	48	8.5— 9.5	4	23.6	1	16;	11	15;	21	14;	26	13
SW Cassiop.	23	03.7	+58	11	9.2— 9.7	5	10.6	3	19;	9	6;	20	3;	25	13
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	1	5;	7	12;	20	2;	26	10
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4	6	18;	18	21				
V Cephei	23	51.7	+82	38	6.0—7.0	0	23.6	1	9;	11	8;	21	8;	26	8

New Variables near the South Pole.—The Harvard College Circular No. 191 gives the results of the study by Miss Leavitt of photographic plates of the region near the south pole for the purpose of discovering new variables. Nineteen new variables were found. All of these are faint and beyond the reach of any but the large telescopes visually. The variation in the brightness of these individual stars ranges from 0.6 magnitude to <4.0 magnitude.

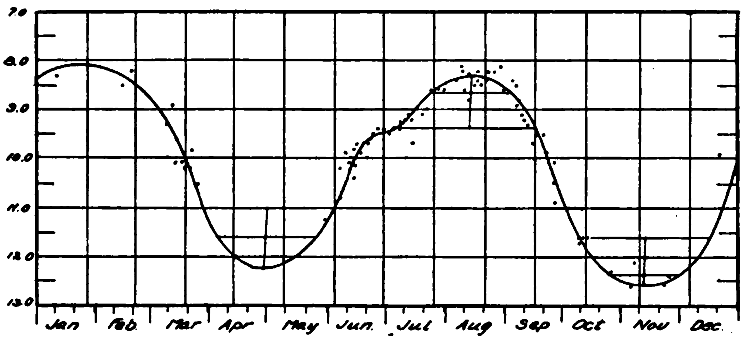
RR Lyrae and RT Aurigae.—In Laws Observatory Bulletins, Nos. 22 and 23, Dr. C. C. Kiess gives results of his study of these two variables.

The first of these is found to vary approximately from the seventh magnitude to the eighth magnitude, the photographic range being slightly less than the visual range which is unusual. The period is short, a little more than a half a day.

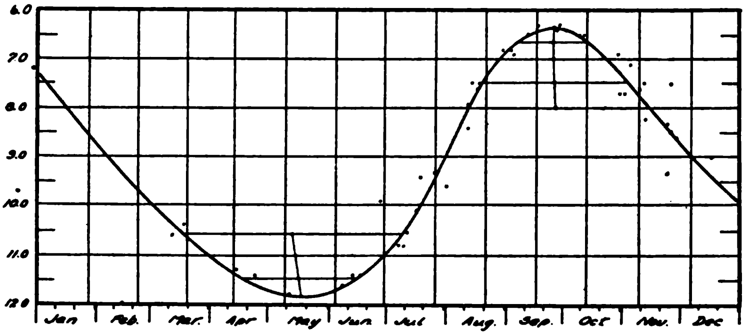
For the latter star new elements are defined as follows:

$$\text{Max.} = \text{J. D. } 2417173.459 + 3^{d}.72806 \text{ E.}$$

These differ very slightly from those assigned to this star by Astbury who discovered this variable in 1905.



LIGHT CURVE OF 181136 W LYRAE FOR 1915
Max Aug. 14 (8.3); min Apr 28 (12.2?); Nov 12 (12.6).
Observations by A.A of V.S O.
Chas B. Lindsley
Cinti., O.



LIGHT CURVE OF 190108 R AQUILAE FOR 1915
Minimum May 18 (11.8); max. Sept 25 (6.4)
Observations by Amer. Assn. Var. Star Observers.
Chas. B. Lindsley
Cinti, O

COMET AND ASTEROID NOTES.

Comet *a* 1916 (Neujmin).—The last two positions of this comet as given in the ephemeris in the Lick Observatory Bulletin No. 280 are given below, because they may reach our readers in time for use by them. They are:

	α	δ
	h m s	° ′
Apr. 29.5	10 23 15	− 9 57.2
May 1.5	10 27 40	−10 25.6

It is seen that the comet is moing rapidly in a southeasterly direction. It is becoming fainter also, being only about one-third as bright as at the time of discovery. It is therefore at the dates given about 11.5 or 12.0 magnitude. According to the elements given it is due to arrive at perihelion again about five years from this time.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Mar.-Apr., 1916.

During the past month observations of 153 variable stars of long period have been recorded by our members, a decided and gratifying advance over the record for the two previous months. A maximum of the variable 074922 U Geminorum was well observed the second week of March, and one of 213843 SS Cygni the third week of March was observed by Messrs. Burbeck, McAteer, and Pickering.

Dr. Edward Gray has accepted the position of surgeon on a Pacific coast line steamer. Mr. S. C. Hunter returns in May from a trip to Japan. Rev. T. C. H. Bouton will spend the month of April in Florida.

The following calculated dates of maxima occuring in May are cited from "The Companion to the Observatory":

May	1	213553	RU Cygni	May	9	*204405*	T Aquarii
	3	081617	V Cancri		16	*170215*	R Ophiuchi
	8	153378	S Urs. Min.		23	171401	Z Ophiuchi
	9	*121418*	R Corvi		28	115919	R Comae
	9	*151822*	RS Librae		29	162119	U Herculis
					29	164715	S Herculis

It has been suggested that we adopt the Julian Day designation of the date of our observations, as the Julian period has been adopted into variable star work by professionals in order to facilitate the combination of observations scattered over a long period of time. As this increases the value of the reports, which is our aim, this suggestion will be adopted, and the time of the observation in every case should be expressed in tenths of a day G. M. T. Will members kindly make a note of this change in the form of the lists submitted to the Harvard College Observatory and to the Secretary. We will also include in our published list in "Popular Astronomy" the negative observations. Even these have a value, and should rightfully have a place in our reports. The following tables are published to facilitate the time and Julian Day conversions:

Table for Converting Standard Astronomical Time to Greenwich Mean Time, when the Tenth of the Day only is Required.

G.M.T Dec.	75th Mer. Eastern		90th Mer. Central		105th Mer. Mountain		120th Mer. Pacific		G.M.T. Dec.
d	h m	h m	h m	h m	h m	h m	h m	h m	d
0.4	3 25	5 48							0.4
0.5	5 49	8 12	4 49	7 12	3 49	6 12			0.5
0.6	8 13	10 36	7 13	9 36	6 13	8 36	5 13	7 36	0.6
0.7	10 37	13 00	9 37	12 00	8 37	11 00	7 37	10 00	0.7
0.8	13 01	15 24	12 01	14 24	11 01	13 25	10 01	12 24	0.8
0.9	15 25	17 48	14 25	16 48	13 25	15 48	12 25	14 48	0.9
1.0	17 49	20 12	16 49	19 12	15 49	18 12	14 49	17 12	1.0
1.1			19 31	21 36	18 13	20 36	17 13	19 36	1.1
1.2					20 37	23 00	19 37	22 00	1.2

Example:—Observations made on January 10, 1916, in the Mountain Belt, between 8:37 and 11:00 local standard time, would equal 0.7 day in G.M.T. and those made between 18:13 and 20:36 would equal 0.1 of the next astronomical day G.M.T. These, expressed in Julian day and tenths, would equal 2420873.7 and 2420874.1, respectively.

VARIABLE STAR OBSERVATIONS Mar.-Apr., 1916.

001046
X Androm.

Mo.	Day	Est.	Obs.
3	1	9.7	Bu

001726
T Androm.

Mo.	Day	Est.	Obs.
3	1	8.5	Bu

001755
T Cassiop.

Mo.	Day	Est.	Obs.
3	11	8.4	R
	23	8.0	M
	25	8.2	R
	30	8.7	Nt
	30	8.4	S

004435
V Androm.

Mo.	Day	Est.	Obs.
3	1	13.4	B

004958
W Cassiop.

Mo.	Day	Est.	Obs.
3	5	10.6	L
	23	9.2	M
	31	9.5	Ba

012350
RZ Persei

Mo.	Day	Est.	Obs.
3	11	10.0	Y

014958
X Cassiop.

Mo.	Day	Est.	Obs.
3	11	9.8	Y
	21	10.0	Y

015354
U Persei

Mo.	Day	Est.	Obs.
3	1	8.4	B
	1	8.2	Bu
	8	7.8	V
	25	8.8	Pi
	25	9.7	R
	26	8.8	Mu
	29	8.6	V

021024
R Arietis

Mo.	Day	Est.	Obs.
3	1	8.6	Bu
	11	8.5	R
	26	8.0	Pi

021143
W Androm.

Mo.	Day	Est.	Obs.
3	1	8.6	Bu

021403
o Ceti

Mo.	Day	Est.	Obs.
3	2	5.3	L
	3	5.1	E

021558
S Persei

Mo.	Day	Est.	Obs.
3	1	9.0	B
	1	8.8	Bu
	11	9.4	R
	31	9.0	Ba

023133
R Triang.

Mo.	Day	Est.	Obs.
3	1	6.2	Bu

024356
W Persei

Mo.	Day	Est.	Obs.
3	1	9.8	Bu
	11	10.1	R
	25	10.0	Pi
	31	9.2	Ba
4	2	10.0	O

030514
U Arietis

Mo.	Day	Est.	Obs.
3	1	9.2	Bu
	11	8.8	Y

032043
Y Persei

Mo.	Day	Est.	Obs.
3	1	9.5	B
	1	9.8	Bu
	11	10.4	R
	31	9.1	Ba

032335
R Persei

Mo.	Day	Est.	Obs.
3	11	12.5	Y
	21	12.0	Y
	31	9.8	Ba

033362
U Camelop.

Mo.	Day	Est.	Obs.
3	11	8.2	R
	31	7.2	Ba

035915
V Eridani

Mo.	Day	Est.	Obs.
3	9	9.5	Pi

041619
T Tauri

Mo.	Day	Est.	Obs.
3	3	10.4	M

042215
W Tauri

Mo.	Day	Est.	Obs.
3	1	9.1	B
	1	9.3	Bu
	3	8.8	M
	11	9.5	O
	11	8.5	R
	23	9.8	Pi
	25	8.9	R
	25	9.6	O
	25	9.6	Ba
	26	9.6	Pi
	31	9.3	Ba
	31	9.3	B
	31	9.6	O
	31	9.5	Nt

043065
T Camelop.

Mo.	Day	Est.	Obs.
3	1	9.2	Bu
	30	8.7	Pi
	31	8.5	Ba

043274
X Camelop.

Mo.	Day	Est.	Obs.
3	1	9.5	Bu
	1	9.0	B
	2	9.3	L
	3	9.1	E
	5	9.3	L
	11	8.7	O
	11	8.4	Y
	23	8.8	O
	25	8.5	O
	26	8.2	O
	29	8.3	V
	30	8.2	O
	30	8.3	Pi
	31	8.2	O
	31	8.4	Ba
4	2	8.2	O
	5	8.2	O

043208
RX Tauri

Mo.	Day	Est.	Obs.
3	3	12.0	E
	3	11.5	M

044617
V Tauri

Mo.	Day	Est.	Obs.
3	1	13.7	B
	31	13.4	B

045307
R Orionis

Mo.	Day	Est.	Obs.
3	1	10.0	Bu

045514
R Leporis

Mo.	Day	Est.	Obs.
2	21	9.3	L
3	1	8.6	Bu
	1	9.5	L
	9	9.3	Pi
	11	8.7	B

050022
T Leporis

Mo.	Day	Est.	Obs.
3	1	9.8	Bu

050003
V Orionis

Mo.	Day	Est.	Obs.
3	3	11.3	M
	4	11.6	Pi

050953
R Aurigae

Mo.	Day	Est.	Obs.
3	1	9.2	Bu
	3	8.9	E
	19	8.7	M
	25	8.5	Ba
	26	8.4	Pi

052034
S Aurigae

Mo.	Day	Est.	Obs.
3	1	8.6	Bu
	19	9.0	M
	25	9.0	Ba

052404
S Orionis

Mo.	Day	Est.	Obs.
3	1	11.0	Bu
	3	11.0	M
	31	12.5	Ba

053068
S Camelop.

Mo.	Day	Est.	Obs.
3	11	9.9	Y

053005
T Orionis

Mo.	Day	Est.	Obs.
2	21	9.3	L
3	1	10.0	Bu
	1	9.5	L
	3	10.4	M
	4	9.5	Pi
	25	10.2	Bu
	26	9.6	Nt
	31	10.4	Ba

054319
SU Tauri

Mo.	Day	Est.	Obs.
3	1.6	9.7	Bu
	3.6	9.6	E
	4.7	9.6	E
	8	9.4	V
	8.5	9.5	E
	9.6	9.5	E
	18.7	9.5	E
	25	9.4	V
	25.6	9.2	Ba
	26.6	9.4	O
	29	9.5	V
	31.6	9.2	Nt
	31.6	9.2	Ba
4	2.5	9.4	O
	5.5	9.5	O

054920
U Orionis

Mo.	Day	Est.	Obs.
3	3	10.2	E
	26	9.7	O
	31	10.0	Pi
4	2	9.7	O

054974
V Camelop.

Mo.	Day	Est.	Obs.
3	1	10.7	Bu
	3	11.0	E
	4	11.1	E
	8	11.4	E
	9	11.3	E
	11	11.3	Y
	30	11.3	B
	30	11.8	Pi
	31	11.6	Ba

055353
Z Aurigae

Mo.	Day	Est.	Obs.
3	1	9.8	Bu
	3	9.7	E
	19	9.4	M
	21	9.9	Y

Z Aurigae

Mo.	Day	Est.	Obs.
3	25	9.6	Ba
	26	9.8	Pi
	26	9.6	Ba
	31	9.9	Nt

060450
X Aurigae

Mo.	Day	Est.	Obs.
3	1	12.4	L
	4	12.3	E
	21	11.9	Y
	31	11.3	B

061647
V Aurigae

Mo.	Day	Est.	Obs.
3	21	10.8	Y

061702
V Monoc.

Mo.	Day	Est.	Obs.
3	1	9.3	Bu
	5	9.2	Pi

063159
U Lyncis

Mo.	Day	Est.	Obs.
3	11	12.6	Y
	31	12.6	Ba

063558
S Lyncis

Mo.	Day	Est.	Obs.
3	4	12.8	E
	11	12.4	Y
	31	12.8	Nt

064030
X Gemin.

Mo.	Day	Est.	Obs.
3	4	12.3	E
	31	12.8	Ba

065111
Y Monoc.

Mo.	Day	Est.	Obs.
3	4	12.7	E

065208
X Monoc.

Mo.	Day	Est.	Obs.
2	21	7.8	L
3	5	7.0	L
	5	7.5	Pi
	31	7.3	Ba

065355
R Lyncis

Mo.	Day	Est.	Obs.
3	31	8.0	Ba

070122a
R Gemin.

Mo.	Day	Est.	Obs.
3	4	11.6	Pi
	8	11.8	E
	26	12.2	Nt

070122
TW Gemin.

Mo.	Day	Est.	Obs.
3	4	8.2	Pi
	8	8.3	E
	26	8.0	Nt

Variable Star Observations Mar.-Apr., 1916—Continued.

Mo.	Day	Est.	Obs.
070122b Z Gemin.			
3	8	12.3	E
	26	12.4	Nt
070310 R Can. Min.			
3	5	10.4	L
	19	9.5	M
	26	9.8	O
	30	9.6	Pi
	31	9.0	Ba
4	5	9.4	O
072708 S Can. Min.			
3	2	9.0	Mu
	5	9.6	L
	5	9.5	Pi
	5	9.4	Mu
	7	9.6	M
	8	9.9	E
	10	10.1	Mu
	11	10.4	O
	21	10.2	Mu
	25	10.6	S
	25	10.0	Pi
	26	10.3	Mu
	30	10.2	Mu
	31	10.4	Ba
073508 U Can. Min.			
3	1	8.6	Bu
	2	9.2	L
	7	9.2	M
	11	9.3	O
	23	9.5	O
	30	9.5	Pi
	30	9.5	O
	31	9.2	B
	31	9.1	Ba
4	5	9.5	O
074323 T Gemin.			
3	26	13.6	Sp
074922 U Gemin.			
3	1.5	13.9	B
	8.6	8.8	V
	8.6	8.9	E
	9.6	9.5	Ba
	9.6	9.2	E
	10.6	9.2	Sp
	10.7	9.4	E
	11.5	9.3	O
	11.5	9.1	Pi
	11.6	9.8	B
	12.7	9.4	E
	18.7	12.3	E
	31.6	13.8	B

Mo.	Day	Est.	Obs.
081112 R Cancri			
3	1	9.0	Bu
	5	8.9	L
	9	8.9	Pi
	25	8.8	O
	31	8.8	O
	31	8.5	Ba
081617 V Cancri			
3	1	8.2	Bu
	9	8.5	Pi
	25	8.6	O
	31	8.8	O
	31	8.7	Ba
082405 RT Hydrae			
3	1	8.1	L
	11	8.2	Bu
	24	8.0	Ho
	30	8.2	Pi
	30	8.6	M
	31	8.2	O
	31	8.2	Ba
084803 S Hydrae			
3	5	11.2	Pi
	11	10.9	B
	30	11.6	M
	31	11.6	Ba
085008 T Hydrae			
3	11	9.8	Bu
	31	11.5	Ba
085120 T Cancri			
3	1	9.8	L
	11	9.4	B
	11	9.8	Bu
090151 V Urs. Maj.			
3	1	10.5	L
	2	10.4	L
	5	10.4	L
	5	10.4	Mu
	8	10.4	V
	9	10.9	Sp
	10	10.5	Mu
	11	11.1	R
	21	10.3	Mu
	25	11.3	R
	26	10.2	Mu
	29	10.2	V
	30	10.0	Mu
	31	11.2	Pi
	31	10.1	Ba

Mo.	Day	Est.	Obs.
090425 W Cancri			
3	30	12.6	Pi
	31	12.8	Ba
093014 X Hydrae			
3	5	8.6	Pi
	11	8.6	Bu
	31	9.2	Ba
093934 R Leo. Min.			
3	3	8.0	M
	5	7.9	Pi
	11	8.8	Bu
	30	8.8	S
	31	8.7	O
	31	8.2	Ba
094211 R Leonis			
3	3	8.4	E
	3	8.4	M
	5	8.7	Pi
	5	9.3	Mu
	5	9.0	L
	10	9.0	Ma
	10	8.9	Mu
	11	9.3	O
	11	9.3	Bu
	21	9.2	Mu
	23	9.6	O
	25	9.0	S
	26	9.3	Mu
	27	9.8	Pi
	30	9.2	Mu
	30	9.6	O
	31	8.6	Ba
4	5	9.9	O
094622 Y Hydrae			
3	5	6.8	Pi
	11	7.0	Bu
	24	6.2	Ho
	31	6.6	Ba
095421 V Leonis			
3	10	13.1	Sp
103212 U Hydrae			
3	11	6.2	Bu
103769 R Urs. Maj.			
3	3	10.3	M
	9	9.9	Ba
	11	10.0	O
	23	11.0	M
	23	11.0	Pi
	25	10.8	S

Mo.	Day	Est.	Obs.
R Urs. Maj.			
3	30	11.2	M
	31	11.2	Pi
	31	10.7	Ba
104620 V Hydrae			
3	5	6.5	Pi
	24	6.3	Ho
	31	6.4	Ba
104814 W Leonis			
3	11	12.8	Y
115919 R Comae			
3	10	12.4	Sp
120012 SU Virginis			
3	25	10.8	Ba
120905 T Virginis			
3	10	10.3	Sp
	25	10.3	Ba
	26	10.1	Sp
	29	10.4	V
121418 R Corvi			
3	3	8.3	M
	24	7.0	Ho
	25	7.0	Ba
122001 SS Virginis			
3	25	7.9	Ba
	26	7.8	Sp
122532 T Can. Ven.			
3	5	10.7	Pi
	11	10.0	Y
	25	9.4	Ba
	31	10.0	M
4	2	9.7	O
122803 Y Virginis			
3	25	12.2	Sp
123160 T Urs. Maj.			
3	8	11.5	E
	10	12.5	Sp
	26	11.6	Nt
	30	11.8	Ba
123307 R Virginis			
3	10	10.1	Sp
	13	10.0	L
	25	10.5	S
	26	10.4	Sp
	30	10.3	Ba
	31	10.7	O

Mo.	Day	Est.	Obs.
123459 RS Urs. Maj.			
3	30	13.7	Ba
123961 S Urs. Maj.			
3	2	8.6	L
	3	9.0	E
	3	8.9	M
	4	9.1	Pi
	8	9.0	E
	9	8.7	Ba
	10	8.7	Sp
	10	8.8	Ma
	11	9.2	O
	11	8.8	Bu
	19	9.2	M
	21	9.6	S
	23	9.3	M
	23	9.9	Pi
	25	8.7	Ba
	25	9.7	O
	26	10.3	Nt
	30	9.8	M
	30	9.8	Ba
4	2	10.0	O
124606 U Virginis			
3	25	9.3	S
	25	8.8	Ba
132422 R Hydrae			
3	13	7.6	L
132706 S Virginis			
3	3	9.0	M
	13	9.2	L
	30	9.6	Ba
134440 R Can. Ven.			
3	5	8.6	Pi
	11	8.8	Bu
	13	8.9	L
	17	8.7	M
	25	9.0	Ba
	30	9.1	S
	30	9.0	M
	30	9.2	O
	31	8.9	Ba
4	5	9.1	O
141567 U Urs. Min.			
3	5	9.1	Pi
	11	9.6	Bu
	25	10.2	Ba
141954 S Bootis			
3	25	12.0	Sp
	30	11.9	Ba

VARIABLE STAR OBSERVATIONS Mar.-Apr., 1916—Continued.

142205
RS Virginis

Mo.	Day	Est.	Obs.
3	30	13.5	Ba

142539
V Bootis

Mo.	Day	Est.	Obs.
3	5	10.0	Pi
	9	10.1	Sp
	11	10.0	M
	25	9.9	S
	30	10.1	O
	30	10.0	Ba
4	5	9.8	O

142584
R Camelop.

Mo.	Day	Est.	Obs.
3	11	9.6	Bu
	11	9.5	O
	25	9.3	O
	25	9.2	Sp
	30	9.2	O
4	2	9.1	O
	5	9.0	O

143227
R Bootis

Mo.	Day	Est.	Obs.
3	30	11.9	Ba

144918
U Bootis

Mo.	Day	Est.	Obs.
3	9	10.6	Sp
	17	9.9	M
	29	10.3	V
	30	10.1	Ba

150605
Y Librae

Mo.	Day	Est.	Obs.
3	13	9.5	L
	30	10.5	Ba

151520
S Librae

Mo.	Day	Est.	Obs.
3	13	10.0	L

151731
S Cor. Bor.

Mo.	Day	Est.	Obs.
3	5	8.5	Pi
	11	6.9	M
	30	8.9	Ba

151822
RS Librae

Mo.	Day	Est.	Obs.
3	13	10.8	L

153378
S Urs. Min.

Mo.	Day	Est.	Obs.
3	5	10.2	Pi
	10	9.4	Mu
	11	9.5	B
	19	8.7	M
	26	9.5	Mu
	30	9.5	Mu
	30	9.8	M
	31	9.6	Nt

154428
R Cor. Bor.

Mo.	Day	Est.	Obs.
3	5.6	6.2	L
	5.7	6.0	Pi
	11.8	6.0	M
	13.7	6.0	L
	23.6	6.1	Nt
	25.6	5.9	Ba
	25.6	6.1	Nt
	25.7	6.0	Pi
	26.6	6.2	Nt
	28.6	6.2	Nt
	29	6.2	Mu
	29.7	5.7	V
	30.6	6.0	O
	30.7	5.8	Ba
	31.6	6.1	Nt
	31.6	5.8	Ba
4	2.6	6.0	O

154536
X Cor. Bor.

Mo.	Day	Est.	Obs.
3	30	13.2	Ba

154539
V Cor. Bor.

Mo.	Day	Est.	Obs.
3	5	8.4	Pi

154615
R Serpentis

Mo.	Day	Est.	Obs.
3	4	9.0	E
	30	7.2	Ba

155847
X Herculis

Mo.	Day	Est.	Obs.
3	23	7.1	Nt
	26	6.8	Nt
	31	6.9	Nt

160021
Z Scorpii

Mo.	Day	Est.	Obs.
3	10	9.6	M

160118
R Herculis

Mo.	Day	Est.	Obs.
3	25	9.3	Sp
	29	9.3	V
	30	9.6	Ba

160210
U Serpentis

Mo.	Day	Est.	Obs.
3	30	8.9	Ba

160221
X Scorpii

Mo.	Day	Est.	Obs.
3	10	10.8	M

160519
W Scorpii

Mo.	Day	Est.	Obs.
3	10	11.0	M

160625
RU Herculis

Mo.	Day	Est.	Obs.
3	30	11.3	Ba

161138
W Cor. Bor.

Mo.	Day	Est.	Obs.
3	30	12.5	Ba

161122c
T Scorpii

Mo.	Day	Est.	Obs.
3	10	11.2	M

162112
V Ophiuchi

Mo.	Day	Est.	Obs.
3	15	8.0	M

162119
U Herculis

Mo.	Day	Est.	Obs.
3	3	11.2	M
	25	11.1	Pi
	30	10.9	Ba

162815
T Ophiuchi

Mo.	Day	Est.	Obs.
3	15	8.8	M

162807
SS Herculis

Mo.	Day	Est.	Obs.
3	5	9.9	L
	25	9.7	Pi
	29	9.8	V
	30	9.9	Ba

163137
W Herculis

Mo.	Day	Est.	Obs.
3	10	9.2	Sp
	11	9.3	M
	25	8.5	Sp
	25	10.4	Pi
	30	8.4	Ba

163172
R Urs. Min.

Mo.	Day	Est.	Obs.
3	3	10.2	E
	5	10.2	Pi
	10	9.5	E
	26	9.2	Sp
	30	9.4	M

163266
R Draconis

Mo.	Day	Est.	Obs.
3	25	7.7	S
	25	7.1	Pi
	30	7.5	M
	30	7.0	Ba

164055
S Draconis

Mo.	Day	Est.	Obs.
3	10	8.4	M

164319
RR Ophiuchi

Mo.	Day	Est.	Obs.
3	15	9.5	M

164715
S Herculis

Mo.	Day	Est.	Obs.
3	25	7.2	Pi
	30	6.6	Ba

165631
RV Herculis

Mo.	Day	Est.	Obs.
3	10	11.1	Sp
	10	11.0	M
	25	11.4	Sp
	30	12.0	Ba

170215
R Ophiuchi

Mo.	Day	Est.	Obs.
3	10	8.1	M

171401
Z Ophiuchi

Mo.	Day	Est.	Obs.
3	30	7.9	V

171723
RS Herculis

Mo.	Day	Est.	Obs.
3	25	9.6	Sp

172809
RS Ophiuchi

Mo.	Day	Est.	Obs.
3	15	11.5	M

175458
T Draconis

Mo.	Day	Est.	Obs.
3	30	11.1	Pi

180531
T Herculis

Mo.	Day	Est.	Obs.
3	25	10.8	Pi

180565
W Draconis

Mo.	Day	Est.	Obs.
3	25	11.9	Pi
	26	11.8	Sp

181103
RY Ophiuchi

Mo.	Day	Est.	Obs.
3	30	9.0	V

181136
W Lyrae

Mo.	Day	Est.	Obs.
3	10	8.3	M
	26	8.5	Sp
	30	9.3	M
	30	9.2	Pi

183308
X Ophiuchi

Mo.	Day	Est.	Obs.
3	30	8.7	V

184205
R Scuti

Mo.	Day	Est.	Obs.
3	5.7	6.1	L
	13.7	5.8	L

184243
RW Lyrae

Mo.	Day	Est.	Obs.
3	26	13.6	Sp

190926
X Lyrae

Mo.	Day	Est.	Obs.
3	10	8.7	M
	30	9.0	M

190967
U Draconis

Mo.	Day	Est.	Obs.
3	10	11.4	M

192928
TY Cygni

Mo.	Day	Est.	Obs.
3	30	9.5	V
	30	9.0	M

193449
R Cygni

Mo.	Day	Est.	Obs.
3	30	10.6	M

193732
TT Cygni

Mo.	Day	Est.	Obs.
3	30	8.8	M

194048
RT Cygni

Mo.	Day	Est.	Obs.
3	30	9.0	M

194632
χ Cygni

Mo.	Day	Est.	Obs.
3	5	7.0	L
	30	8.6	M
	25	8.2	Pi

195849
Z Cygni

Mo.	Day	Est.	Obs.
3	25	11.9	Pi

200647
SV Cygni

Mo.	Day	Est.	Obs.
3	25	8.9	Pi
	30	8.4	M

200938
RS Cygni

Mo.	Day	Est.	Obs.
3	25	7.4	Pi
	30	6.9	M

201647
U Cygni

Mo.	Day	Est.	Obs.
3	25	7.6	Pi
	30	8.8	M

202539
RW Cygni

Mo.	Day	Est.	Obs.
3	30	8.9	M

202946
SZ Cygni

Mo.	Day	Est.	Obs.
3	30	10.3	M

210868
T Cephei

Mo.	Day	Est.	Obs.
3	2	8.7	L
	25	9.1	S
	26	9.4	Nt

213244
W Cygni

Mo.	Day	Est.	Obs.
2	21	5.8	L
3	13	5.7	L

213678
S Cephei

Mo.	Day	Est.	Obs.
3	30	9.6	S

213843
SS Cygni

Mo.	Day	Est.	Obs.
2	21.3	11.5	L
3	13.7	11.7	L
	25.8	8.3	Pi
	29.8	8.6	Bu
	30.8	8.2	Pi
	30.1	8.4	M

235350
R Cassiop.

Mo.	Day	Est.	Obs.
3	1	9.6	B

No. of observations 536; No. of stars observed 153; No. of observers 17.

JULIAN DAY CALENDAR FOR 1916.

Month		Jul. Day	Month		Jul. Day	Month		Jul. Day
January	0	2420863	May	0	2420984	September	0	2421107
February	0	20894	June	0	21015	October	0	21137
March	0	20923	July	0	21045	November	0	21168
April	0	20954	August	0	21076	December	0	21198

To convert the calendar date to Julian Day, add to the value given for the zero (0) of each month, the day in question. Thus: January 10th, 1916 equals J. D. 2420873.

The following members contributed to this report:—Messrs. Bancroft Bouton, Burbeck, Eaton, Hoge, Lacchini, Mach, McAteer, Mundt, Nolte, Olcott Pickering, Richter, Spinney, Vrooman, Miss Swartz and Miss Young.

WILLIAM TYLER OLCOTT,
Corresponding Sec'y.

Norwich, Conn.
Apr. 10, 1916.

COMMUNICATIONS.

An Unusual Meteor.—I wish to report an observation of mine of a brilliant fire-ball about 7 p. m. 1916 April 1. It was one of the largest that I ever saw, was moving very slowly, and seemed to leave portions of its substance in its trail in the form of sparks. It came from an easterly direction and moved almost due west. It was moving so slowly that I could easily see its nucleus. When I first saw it its motion was such that I unconsciously leaned over in my saddle for fear of it striking me. I heard no explosions nor any other sound although I listened closely. I believe that when it vanished it was less than a mile from my position.

WM. H. CASSELL, M. D.

WYTHEVILLE, Va.

GENERAL NOTES.

Miss Anna D. Lewis of Mt. Holyoke College has been appointed professor of mathematics at the Kentucky College for women. (*The Am. Math. Monthly*, March 1916).

Professor M. G. Mittag-Leffler, the distinguished Swedish mathematician, and his wife, on his seventieth birthday, set aside their entire fortune for the foundation of an International Institute for pure mathematics. (*Science*, April 14, 1916).

Dr. R. G. Aitken, astronomer of Lick Observatory, gave the regular monthly lecture before the Stanford University Faculty Science Association on March 22, 1916, on the subject of "Binary Stars." (*Science*, Apr. 7, 1916).

Dr. John A. Brashear, president of the American Society for Mechanical Engineers, was given the doctorate of laws at the Charter Day exercises of the University of Pittsburgh on March 20. On the evening of that day, a dinner was held in honor of the late Samuel P. Langley,secretary of the Smithsonian Institution and previously director of the Allegheny Observatory. The speakers included Dr. John A. Brashear and Dr. J. W. Holland. (*Science*, Apr. 7, 1916).

The Meeting of the Astronomical Society of the Pacific was held on March 25, at the Students Observatory, Berkeley, when the following program was presented: "Comet *a* 1916 (Neujmin)," by Miss Jessica M. Young; "The Riefler Clock", by Professor R. T. Crawford; "On the Universality of the Law of Gravitation", by Professor A. O. Leuschner. (*Science*. Apr. 7, 1916).

Actual Time of Signals from the U.S. Naval Observatory, March, 1916.

Day	Time of signals Noon	Error	Time of signals 10:00 p.m.	Error	
	h m s		h m s		
1	12 0 0.00	.00	9 59 59.96	—.04	
2	11 59 59.91	—.09	9 59 59.89	—.11	
3	11 59 59.87	—.13	9 59 59.85	—.15	
4	11 59 59.99	—.01	10 0 0.03	+.03	
5	12 0 0.05	+.05	10 0 0.06	+.06	Sunday
6	12 0 0.10	+.10	10 0 0.09	+.09	
7	12 0 0.11	+.11	10 0 0.14	+.14	
8	12 0 0.10	+.10	10 0 0.10	+.10	
9	11 59 59.99	—.01	9 59 59.99	—.01	
10	12 0 0.00	.00	9 59 59.99	—.01	
11	11 59 59.98	—.02	10 0 0.01	+.01	
12	12 0 0.02	+.02	10 0 0.02	+.02	Sunday
13	12 0 0.01	+.01	10 0 0.00	.00	
14	11 59 59.99	—.01	9 59 59.99	—.01	
15	11 59 59.97	—.03	9 59 59.98	—.02	
16	12 0 0.01	+.01	9 59 59.98	—.02	
17	12 0 0.02	+.02	9 59 59.99	—.01	
18	11 59 59.99	—.01	9 59 59.99	—.01	
19	11 59 59.98	—.02	9 59 59.97	—.03	Sunday
20	12 0 0.01	+.01	10 0 0.01	+.01	
21	11 59 59.99	—.01	9 59 59.99	—.01	
22	11 59 59.98	—.02	9 59 59.98	—.02	
23	11 59 59.98	—.02	9 59 59.97	—.03	
24	12 0 0.00	.00	10 0 0.00	.00	
25	12 0 0.00	.00	10 0 0.00	.00	
26	11 59 59.99	—.01	10 0 0.01	+.01	Sunday
27	12 0 0.00	.00	10 0 0.01	+.01	
28	12 0 0.01	+.01	10 0 0.02	+.02	
29	12 0 0.01	+.01	10 0 0.03	+.03	
30	12 0 0.03	+.03	10 0 0.03	+.03	
31	12 0 0.02	+.02	10 0 0.04	+.04	

Maximum error: Mar. 3, —0.15 sec.

Constant to be added to above errors to give error of radio signals from

Arlington	+0.02 sec.
Key West	+0.27

J. A. Hoogewerff,
Captain U.S. Navy
Superintendent.

U.S. Naval Observatory,
Washington, D. C.
Apr. 8, 1916.

The Greatest Need of Astronomy.—The greatest present need of astronomy, the grandest science, is not more big telescopes and big observatories, but a more favorable public opinion. Never in the history of the world have astronomical appliances been so great as they are at present, and never before has general interest in astronomy been so limited. The subject has been banished from nearly every high school in the land. The days have passed when Sir Richard Proctor could deliver a popular astronomical lecture in a crowded hall. The announcement in almost any city in the United States that the most learned or the most eloquent astronomer in the world is to deliver such a lecture would not now attract the interest that it would have attracted twenty-five or fifty years ago. When one considers the wonderful progress that the science has made, and the money that has been devoted to it, this state of things is appalling. Even the private schools, which retained astronomy as a cultural topic longer than the public schools, have for the most part discontinued it. The recent organizations of Boy Scouts, Camp Fire Girls and Woodcraft Indians apparently feel the need of a little astronomical instruction, as they recognize the need of a few drops of vanilla in a big can of ice cream. One organization devoted to outdoor life requires its members to know Polaris and the Great Dipper, but limits the *requirement* to that. Ye gods, upon what meat doth this our Caesar feed that he is grown so puny! No meat has been fed to this great giant, astronomy, so far as is known to the general public. I have recently lectured before Teachers' Institutes and high schools in a large number of the leading cities of the United States, but from not one of the many of whom I have asked this simple question have I received an answer: "Which way is the moon moving in the sky? Is it north, south, east, west, or what other point of the compass?" Several persons have ventured to say that it is going west as they had seen it set in the west and rise in the east. One only needs to question a social assembly or a gathering of educated men, or any school, to ascertain not only how deep is the ignorance but also how little the real interest in the subject whose grandeur so appeals to astronomers. Even if such persons do know that it is Venus in the west and the Pole Star in the north, there is but little mental grasp of the significance of the fact. With the majority it means almost as much as to say, "An oak tree is on the north side of my lot, and a maple on the east." But the situation is improving and the purpose of this article is to point out the manner in which it may be improved more rapidly. I believe the time has come when every community should have its moderate sized observatory, not with a large telescope, but preferably with several small ones, and that no technical work should be attempted. The librarian of a popular local library does not devote himself to technical bibliography but to the assisting of the public. Such must be the new type of astronomer. These popular observatories should not be equipped with a dome. A dome is right for technical research, but absolutely useless to a crowd of visitors. I would build a square cornered building with an ordinary, sloping roof but I would build it twelve or eighteen feet wide and twenty-four or thirty-six feet long, with a skeleton framework of the same size, on which I would roll the roof that should be divided into two sections, one gliding one way and the other the other. By this method an unobstructed view of any part of the heavens may be obtained, and it is ideal for constellation work. Within this observatory I would have at least four telescopes but none more than a nine-inch aperture. The ideal equipment would be a five-inch, a six-inch, an eight-inch and a nine-inch. In small communities a six-inch and a four-inch would be satisfactory.

At Sound Beach, Connecticut, has recently been completed what I think is the first community observatory in the United States, and I also think the largest in the United States with a roof completely removable. But a very big one is not required to justify so superlative a statement. Ours is only twelve by twelve feet and so far as I know the next largest with movable roof is considerably smaller, but it is found to be large enough for the students at the University of Pennsylvania, at Philadelphia.

For such an observatory, a solid cement foundation is essential. Our new one has a solid block twelve by twelve feet and five feet deep made by blasting the stones from a neighboring stone wall and filling in with cobbles set in cement. The telescope is a six inch on pillar mount, the last work of the late Carl A. R. Lundin of The Alvan Clark & Sons Corporation. The instrument was placed in position in October; Mr. Lundin died in November.

Money for this observatory came from all the country from Maine to California. It is therefore not strictly a community observatory as it should have been, but a national, popularizing institution. The total cost was about thirteen hundred dollars and the observatory contains every essential requisite; even some adornment of the grounds is included in the bill. For five thousand dollars a grand community observatory could be erected on this plan. The astronomical observatories of the United States have not even considered the question of really popularizing the subject, a charge that I make deliberately, and can prove by the present state of lack of popular interest. We continue to pile up tomes of technical information for the few, while thousands of business men and women, of schoolgirls and schoolboys have not the remotest notion of the difference between a planet and a star, and still fewer know or seem to care that one of the planets is surrounded by rings. Astronomical science has been allowed to become a failure in the general uplift of humanity. If those interested in the subject are wise, they will recognize and acknowledge this unpleasant fact, and will right about face to devote their energies to the establishing of observatories not restricted to the computing of the parallax of a star, or to the discovery of another spectroscopic binary. They will try to make clear to the general public some of the common place things of the heavens. I deliberately assert that every technical observatory in these United States is a failure and a farce, so far as instructing the community at large is concerned. The visitors go not to become acquainted with the heavens but to become acquainted with the observatory, to say that they have met such an astronomer, and that they have looked for about a minute and a half through the big telescope. That is a knowledge of the observatory, and extremely limited. It has not lifted in the slightest degree the shades of ignorance that obscure the heavens. The great observatory of Allegheny built by the citizens of Pittsburgh and Allegheny, at a cost of more than three hundred thousand dollars, is absolutely useless to those citizens, since the huge telescope, the lens of which costs thirty thousand dollars, has never been and never will be looked through by even one citizen of Pittsburgh or of Allegheny, because it is not adapted to visual observation; it is a photographic lens. The visitors to that big observatory still look through a small Alvan Clark glass, the same that Langley used more than half a century ago. I say this in no spirit of adverse criticism. I am glad that the Allegheny observatory exists. I am glad that it is devoting its energies to technical work. It is needed for such investigations. All speed to its work.

But what amuses me is that the people of Pittsburgh and Allegheny think that they have an observatory. They have nothing of the kind. The technical workers have an observatory. I sincerely hope they will keep it and make good use of it, but what am I pleading for is that those cities and every other city in the United States will establish an observatory that shall be for the people and not exclusively for the few that are skilled in technical research.

It was Henry David Thoreau who said that he became alarmed when he had walked a mile into a forest and did not enter it. Let us, lovers of astronomy, be alarmed when we think of the gigantic telescopes now being erected at Mount Wilson, California, and of the other great observatories, and seriously ask ourselves, have the people of the United States one single observatory that to them is really worth while? Yes, they have. For a year we labored, and struggled, and talked, and wrote, and begged our friends from Maine to California until we accumulated $1,052.43 to erect in the little town of Sound Beach, Connecticut, a sheet iron building twelve by twelve feet, with a telescope six inches in aperture, only six inches but big enough for the place and useful. Let this act as an exemplar to other and larger places that shall establish observatories to resuscitate the gasping, dying interest in popular astronomy. I believe the question asked by "The Monthly Evening Sky Map" and by a number of other publications, "What is the matter with astronomy?" is to be answered in only one way. The matter is with the astronomers; they are thinking too much of themselves and of the technicalities of the science. The final test of anything is the general public welfare, but a highly specialized interest, like a highly specialized double rose, is in danger of going out in what Dr. Morris calls "a blaze of glory." Nations have done that, families have done it, and beware or the science of astronomy will do it.

It is encouraging to know that the greatest popularizing philanthropist of the United States is awake to these facts. In the March number of the "Women's Home Companion," Andrew Carnegie asks, "What are among the best practical uses to which wealth may be put?" He places first, great universities; second, astronomical observatories completely equipped to carry forth our knowledge of the universe and our earthly relations to it. And although he has devoted millions of dollars to the establishing of popular libraries he modestly places such libraries third upon the list. But look out. Everybody knows that the force of an observatory and library should be centrifugal, but danger threatens in establishing more observatories lest the effect shall become centripetal.

EDWARD F. BIGELOW.

ArcAdia: Sound Beach, Connecticut.

The General Ignorance of Astronomy.

Venus, Jupiter, and the Zeppelins.

NOTE.—The following item translated by Dr. Clifford C. Crump from a paper by Camille Flammarion in *L' Astronomie* for March 1916 shows the lack of astronomical knowledge, lamented in the preceding paper by E. F. Bigelow, to be more or less general. [EDITORS].

"Since I published in the New York Herald a chart on which I marked with circles from west to east, the positions of the planets visible in our beautiful winter sky so handsomely starred, I have received the following letter:

"'We are here at Rouen, three zealous readers of the New York Herald, and also members of the "Societé Astronomique de France," we meet almost every day at the "Place Boieldieu" and we love to talk about astronomy. Not long since while looking at your celestial chart we saw at once that your numbers 1 and 2, at the side of the chart, and to the west, represented Venus and Jupiter, which were very near each other on the night of the thirteenth and fourteenth. They also represented, without doubt, the lights of the Zeppelin which alarmed our beautiful city of Rouen Saturday evening.

" 'In fact, the rumor was current here that this aeriel apparition had been seen to arrive from Harve, brilliant from the south west, without any one being able to distinguish its form or hear its motor. Many eyes followed this double lighted flyer down to the horizon: two lights, forward and aft, until it disappeared at eight fifteen in the western haze without having caused any damage, or having thrown a single bomb.

" 'The most amusing part of the story is that at Rouen the alarm was complete As soon as the "enemy's fires" had been noticed, a shot from the cannon was fired as a warning, the fireman patroled the streets shouting "On guard!", and an hour later "Back to your quarters." All the danger had passed: Venus and Jupiter had set before the eyes of the citizens of Rouen.'

"Since the beginning of the war, there has passed scarcely a month without our Bulletin having discovered analogous confusion, and notably for four months, thousands of ignorant people have taken Jupiter for a dirigible. The position of the double luminary on the south-west horizon, the time of its appearance and disappearance, the apparent path of this aerial ship with head-light (Venus) and aft-light (Jupiter), all contribute to show us that many people are living on our earth in utter ignorance of astronomy, without knowing where they are, and without surmising the marvels of the universe.

"They had at Rouen exactly the same talk as at Paris in the "Place de l'Etoile," "Place de la Concorde," at Montmartre, and in other places in France as we have already mentioned.

"Among a hundred citizens there is scarcely one who ever forms an idea of astronomic realities. The multitude have eyes which do not see. The Chaldean shepherds and the contemporaries of Homer lived better, in truth, than we, and in closer touch with nature. Where is progress?"

THE SPECTRUM.

In silence flowing through a flawless glass
As clear as diamond or supernal space,
A tide of countless sunbeams swiftly pass
And leaves behind not e'en a fading trace;
A warm, soft stream of strong, resplendent light
Pours through my crystal glass—lo! On yon wall
A gorgeous band appears—O splendid sight!—
Prismatic colors like a rainbow fall.

The slower red, the orange, yellow, green,
The blue, the indigo. swift violet,
Like messengers from bright King Sol, are seen
As beautiful as clouds when he has set.

More iridescent than Earth's jewels bright
Upon my wall there shines that spectrum's light!

Charles Nevers Holmes

Newton, Mass.
41 Arlington St.

PLATE XVII.

William Frederick King (1854-1916)
Lately Chief Astronomer for Canada.

Popular Astronomy.

Vol. XXIV, No. 6. JUNE-JULY, 1916. Whole No. 236

W. F. KING, LATE CHIEF ASTRONOMER FOR CANADA.

C. A. CHANT.

The death of Dr. W. F. King, Canadian Chief Astronomer and Director of the Dominion Astronomical Observatory, Ottawa, causes a decided vacancy in the scientific world of Canada. He was of a very quiet and retiring nature and any recognition which he received was purely through merit. A brief consideration of the many appointments he held will show that his life was a very active and useful one.

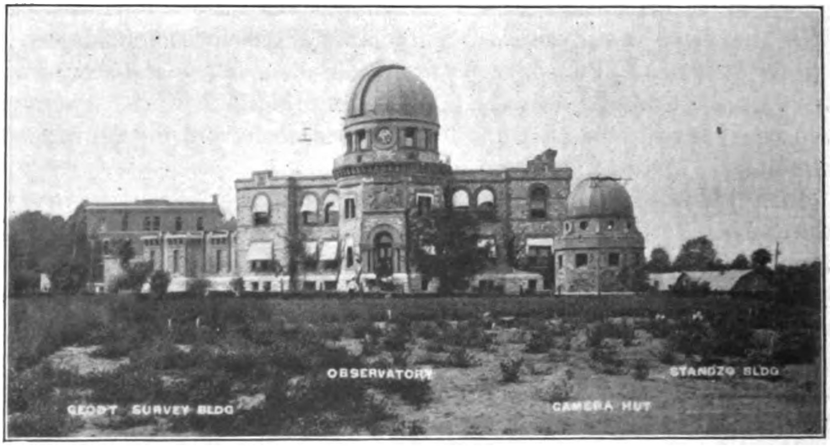
William Frederick King was born at Stowmarket, Suffolk, England, on February 19, 1854, and came to Canada with his parents in September, 1862. He received his preliminary education at the public and high schools of Port Hope, Ontario, and in September, 1869, matriculated into the University of Toronto; but before he received the B. A. degree he began his astronomical work. From September 1872 to December 1874 he acted as sub-assistant astronomer on Her Britannic Majesty's North American Boundary Commission, delimiting the boundary between the United States and Canada from the Lake of the Woods to the Rocky Mountains. In June 1875 he graduated from the University, winning the gold medal in mathematics.

In 1875-76 he was astronomical assistant on special surveys in the North West Territories, and on November 21, 1876, he was admitted a Dominion Land Surveyor and a Dominion Topographical Surveyor. The qualifications for the latter are very technical and difficult and he was the first one to receive the commission. From 1877 to 1881 he was in charge of the astronomical section of the special survey, and on June 13 of the latter year he was made Inspector of Surveys, which was his first permanent appointment in the Department of the Interior.

After this came numerous commissions. From 1885 to 1899 Dr. King was a member of the Board of Examiners for Dominion Land Surveyors. On July 1, 1886, he was appointed Chief Inspector of Surveys, and four years later, in 1890, was made Chief Astronomer of the Department of the Interior. On September 12, 1892, he was appointed H. M. Commissioner under the convention of July 22, 1892, for the survey of the Alaska boundary and of the water boundary in Passamaquoddy Bay, between Maine and New Brunswick. During 1898 and 1899 he was attached to the Joint High Commission at Quebec and Washington as expert on boundary matters. On September 30, 1899, he was reappointed on the reorganized Board of Examiners for Dominion Land Surveyors, and on November 29 of the same year he became Commissioner for demarcation of the provisional Alaska boundary under the Modus Vivendi of October 29, 1899.

On September 28, 1901, he was appointed Commissioner to coöperate with the state of New York in the renewal of the boundary line from the Richelieu to the St. Lawrence, and on July 10 of the following year was appointed H. M. Commissioner under agreement for re-survey and renewing of monuments from Lake Superior to the Pacific Ocean. On November 11, 1902, he was appointed Canadian Commissioner for re-survey of the Quebec-New York boundary. In April 1903 he was attached to the staff of the British Agent, assisting in the preparation of the case for the Alaska Boundary Tribunal. In December 1903 he was made a member of the International Waterways Commission, which appointment he held until February 1907.

On January 29, 1904, Dr. King was appointed H. M. Commisioner for survey and delimitation of the Alaska boundary under award of the Tribunal made on October 20, 1903; and in April of the same year he negotiated with the United States Commissioner the definition of that portion of the boundary which was left undetermined by the Tribunal which met in London. On April 15, 1905, he became Director of the newly-established Dominion Astronomical Observatory. On



THE DOMINION OBSERVATORY, OTTAWA, CANADA.

July 7, 1906, he was appointed H. M. Commissioner for surveying the boundary from the Richelieu to the St. Croix river, and on July 23 of the same year he received the appointment of H. M. Commissioner for survey of the 141st meridian under the convention of April 21, 1906.

On April 6, 1908, he was appointed representative of the Canadian Government in negotiations relative to the uses of international waters for the purposes of irrigation. In June 1908 he was named H. M. Commissioner under the Boundaries Delimitation treaty of April 11, 1908. During 1909 he was representative of the Canadian Government in the Passamaquoddy Bay negotiations which resulted in the treaty of May 21, 1910. On April 20, 1909, he was made Superintendent of the Geodetic Survey of Canada, then just initiated. His commission as H. M. Boundary Commissioner under the treaty of April 11, 1908, is dated October 6, 1915, and is under the Royal Sign Manual.

One cannot read the above list of appointments without recognizing the extreme value of Dr. King as a public servant, and we are not surprised that various honors were bestowed upon him.

On June 11, 1904, the University of Toronto conferred on him the degree of LL. D. (Honoris Causa). In the work of the Royal Astronomical Society of Canada Dr. King took great interest, and was active in the formation of the Center at Ottawa. He became its first president, and, besides, he was Honorary President of the whole Society from 1906 until his death. He was made a Fellow in 1909.

In March 1907 he was elected Honorary President of the Association of Dominion Land Surveyors. In 1908 he became Fellow of the Royal Society of Canada; in 1910 and 1911 he was vice-president, and in May 1911 was elected president.

In June 1908 he was created C. M. G., that is, Companion of the Order of St. Michael and St. George. This honor is conferred by the British sovereign. Since 1908 he was a member of the society now known as the American Astronomical Society, and in December of the year just named he was made Honorary member of the Mexican Astronomical Society.

For the marked activity in astronomical matters in Canada during recent years Dr. King should receive much credit. After many years of effort the beautiful brown stone building of the Dominion Observatory was erected, and around it have been grouped various buildings for the Geodetic Survey and other branches of the service. It is to be regretted that he did not live to see the completion of the great 72-inch reflecting telescope and the buildings to be attached to it at the Victoria station of the Observatory. It is expected that the instrument will be in operation in the autumn and that a regular program of work will be entered upon next spring.

With so many administration duties to perform Dr. King had little leisure for original scientific contributions. I might mention, however, a valuable paper on "Least Squares", printed in the Journal of the Royal Astronomical Society of Canada, and one on "The Geometry of Orbits", which appeared in the Astrophysical Journal. In the latter is presented an entirely original and ingenious method for rapidly obtaining, by graphical means, the elements of the orbit of a spectroscopic binary. This method has been found very useful at the Dominion Observatory and elsewhere.

It has been said that there is no better way to know a man than to camp with him for two or three weeks. The present writer was acquainted with Dr. King for a considerable number of years, but in 1905 he had the privilege of closely associating with him in the camp at North West River, Labrador, whither we had gone to observe the total eclipse of the sun. On cold evenings as we gathered about the campfire and joined in the general entertainment with song or joke, Dr. King threw aside somewhat the cloak of reticence in which he was usually wrapped and gave us some of Bret Harte's poems. He stood the camping test; the nearer we came to him, the more did his sterling character show itself.

In church work Dr. King was identified with almost every department of Christian activity. At the time of his death he was representative to the provincial and general synods of the Anglican Church.

On the 13th of June 1911, to commemorate the thirtieth anniversary of the director's first appointment in the Department of the Interior, his united staffs presented him with a magnificent loving-cup, upon which is engraved the record of his achievements, appointments and academic distinctions.

Dr. King's health had not been very good for some time but he was able to continue his work. However, early in the year he was advised to take a rest at a health resort; he did so, but there was no improvement, and he returned to his residence near the Observatory, where he passed away on Easter Sunday, April 23.

To mourn his loss he left his widow, Augusta Florence Snow, daughter of John A. Snow, D.L.S., whom he married in 1881; two sons, Frederick W. and Edward A., at home; a daughter, the wife of Mr. R. M. Motherwell, astronomer at the Observatory; and a sister, Mrs. James Reid, of Port Hope, who was with him during his illness.

Toronto, Ont.

THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

[*Continued from page 303.*]

The Rosa Ursina.*

Frequent mention has been made of the *Rosa Ursina*. This was Scheiner's great book on the solar spots. A ponderous quarto of nearly eight hundred pages, of which Delambre very unjustly remarks, "There are few books so diffuse and so void of facts. It contains 780 pages, but there is not material in it for 50." It was devoted exclusively to the subject of the sun and its spots, and contained observations extending over a period of more than sixteen years. The title, eminently suitable for a work of such magnitude was, *ROSA VRSINA, SIVE SOL, EX ADMIRANDO FACVLARVM & Macularum suarum Phoenomeno VARIVS, NECNON Circa centrum suum & axem fixum ab occasu in ortum annua, circaq. alium axem mobilem ab ortu in occasum conuersione quasi menstrua, super polos proprios, Libris quatuor MOBILIS ostensus,* a CHRISTOFORO SCHEINER GERMANO SVEVO, E SOCIETATE IESV. AD PAVLVM IORDANVM II. VRSINVM BRACCIANI DVCEM. BRACCIANI, Apud Andream Phaeum Typographum Ducalem. Impressio coepta Anno 1626, finita vero 1630. Id Iunij.

For an explanation of this extraordinary title, we quote Kästner, who remarks in his *Geschichte der Mathematik*:†

> Weil der damalige Herzog von Bracciano aus die Familie Ursi [Orsini] war, und weil die liebe Sonne nichts dagegen sagt, wenn man sie mit einer Rose vergleicht, so heisst das Buch von der Sonne, dem Herzog dedicirt, Rosa Ursina.

The book was dedicated to Paulus Jordanus II, Duke of Bracciano, a member of the house of Orsini. The rose was the emblem of the Orsini family, and as a delicate compliment to his patron, Scheiner proclaims the sun, "The Rose of the Orsini"! The dedication is well enough, for doubtless somebody had to pay for the publication, but that the mighty orb of day should be presented to the Duke as a bouquet, seems to be carrying the compliment a little too far. This motif—"The Sun, the Rose of the Orsini"—is carried out through all the book. On the reverse of one of the title pages (Plate XVIII) is a portrait of the Duke, Paulus Jordanus, himself, surrounded by a wreath made up of alternate roses and suns well supplied with spots.

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* I take pleasure in acknowledging my indebtedness to Professor E. B. Frost of the Yerkes Observatory for the loan of the copy of the Rosa Ursina from which the accompanying illustrations were made.

† Band 4. p. 149.

A picture on the main title page (reproduced in Plate XIX) shows a sort of mountain surmounted by two rose-bushes; three bears in as many caves, the entrances of which are gracefully draped with entwined roses, are performing various duties. Above and below are the mottoes, "Rosa Ursina", "Ursa Rosina". These "rosy bears" naturally furnished Scheiner's enemies with a target for their jokes. Galileo writes to his friend Fulgenzio Micanzio, 9th of February 1636:*

> I admire your persistence in reading the Rosa, in which there is so much pompous childishness. But you will tell me that the very fact that it contains such an excessive amount of this causes no small joy. And who will not pause in considering the cleverness in printing the three she-bears in the three caves, one of which perceives the spots on the sun, the other licks her cubs, and the third sucking her paws? With two such appropriate mottoes (Constans industria format; Ipse alimenta mihi), and the clever transposition $\frac{\text{Rosa Ursina}}{\text{Ursa Rosina}}$. But why should I relate the playful pranks of these little animals for they are innumerable.

It is somewhat difficult to get at the subject matter in this book, which is an interminable labyrinth of words. Page after page, with great double columns, filled with arguments, corollaries, lemmas, queries and answers, without number or end. Even the smallest details are discussed forward and backward, through secondly and thirdly, occasionally up to thirty secondly and even fortiethly, in the most elaborately prosy and prolix fashion, and one can only wonder that four and not forty years were required to finish this enormous work. Nevertheless the book itself is a splendid example of the printer's art of that day, and when one recalls that printing was scarcely two hundred years old, one can but admire the clear and legible typography and the fine and beautifully made engravings.

Obviously it will be impossible to condense all the material of value in the *Rosa* (and there is more of it than Delambre would have us believe) into the limited space of this paper. But there is such a wealth of information concerning the phenomena of the sun's surface, obtained through the unusual skill and perseverance of Scheiner as an observer, that in justice alone the more prominent facts must be mentioned.

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* *Gal. Op.* **16**, 391.

In the preface, "Ad Lectorem" Scheiner relates the history of his discovery of the solar spots, as follows:*

> Therefore in 1611 at the University of Ingolstadt, I, Professor of Science, in the month of March, having climbed to the tower of the Temple and directed the telescope at the sun, weakened proportionately by a moderate cloud; not as a result of any previous report, but spontaneously, led by my desire of examining the sun, I first found solar spots. My companion was J. B. Cysat, a student of theology, who at that time strongly urged me to prepare colored glasses, and while I was doing this, in the month of October of the same year there came again as there will, some days overcast with light clouds inviting observations of the sun, so that I directed my telescope from my bed-chamber......that is, on the 21st day, German Astronomical Time 21 hours; at 9 in the morning, and I saw spots for the second time. And I showed them to many other Fathers and students, until 10 o'clock, at which time Father Adam Tanner perceived the same spots from his bed-chamber......on account of some previous rumors, as he says, of which, however, not the faintest whispers had reached my ears before the spots were first seen by me. For the March observations of these, which were the first, I had not divulged up to that time.

The body of the work is divided into four books. The first of these is largely a denunciation of Galileo, with an attempt by the author to defend himself against the accusations made in the *Saggiatore.* It contains an account of the author's claims for priority of discovery, and a criticism of Galileo's observations and theory of the spots, as contained in the *Istoria,* all of which are related with wearisome longwindedness in some sixty odd pages. In this first book Scheiner gives† a catalogue of the errors into which Galileo had fallen in his reasonings concerning the spots. These errors, which are divided into 24 heads, and were exploited with evident glee by Scheiner were very obvious and were subsequently corrected by Galileo in the *Dialogues on the Two Chief Systems of the World.* This catalogue of errors put Galileo into a rage, as we learn from the letter to Micanzio, in which the "rosy bears" are ridiculed. Galileo continues:‡

> This pig, this great malignant ass [that is to say, Scheiner] makes a catalogue of my errors, which result from one only, which was at first unknown to him as it was to me, namely, the very small inclination of the sun's axis to the ecliptic. I am sure that I discovered it before he did, but had no occasion to mention it except in the *Dialogues.* But let the fellow see his bad fortune, for he was unable to deduce anything remarkable from this observation, while I discovered through it the greatest secret that there is in nature [meaning the revolution of the earth about the sun], and this discovered by me, and comprehended by him after my announcement, to his extreme wonder, is what has most mortally transfixed him, and aroused him to canine rage against me; since it has been my good fortune alone to observe so many and such great novelties in the heavens, and from them to deduce such great consequences in nature; of which this is, one might say, the greatest. And the unfortunate man who so long held in his hand such a precious jewel did not know how to recognize it.

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* *Rosa Ursina,* leaf 14.

† *Ibid.* 45.

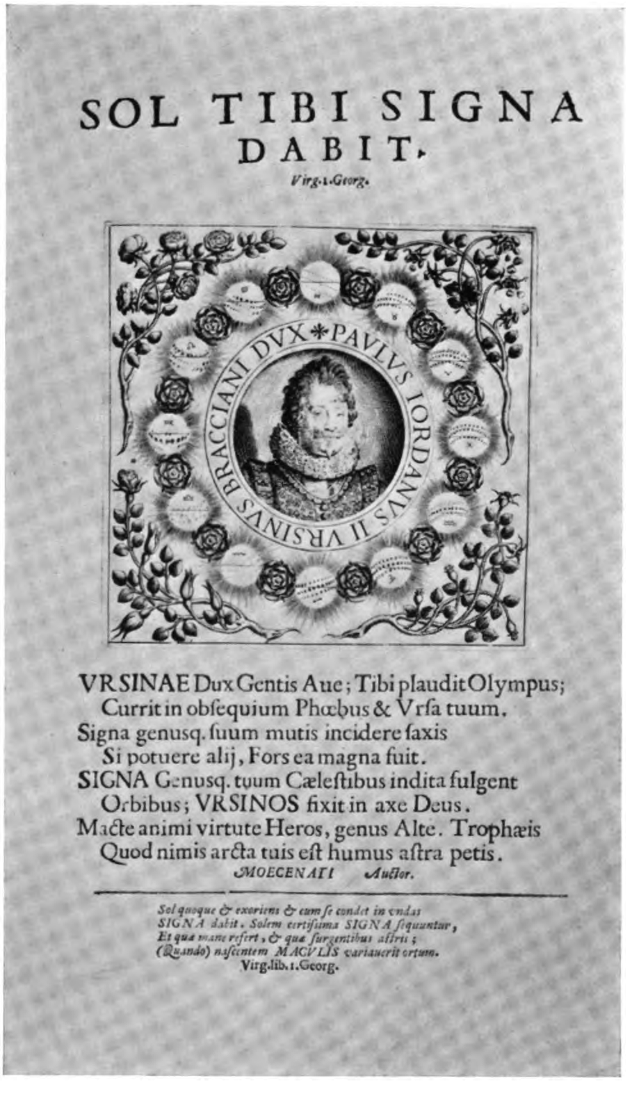
‡ *Gal. Op.* **16**, 391.

This "error" that Galileo refers to,—the slight inclination of the sun's axis to the ecliptic, may have been observed by Scheiner before Galileo, as Scheiner was a careful and painstaking observer. At all events Scheiner is the first to mention it. The inclination of the sun's axis to the ecliptic determines the positions and the aspects of the paths of the spots as they cross the disk, with the changes in the curvature and direction of these paths at different times of the year, and is of consequent importance. The fact that Scheiner was unable to deduce from these changes that which Galileo recognized to be their true cause, namely, the different positions of the earth in its orbit around the sun, was undoubtedly due to his deeply rooted conservatism and adherence to the older ideas. But the changes in the paths of the spots could equally well have been explained by the theories of the Peripatetics, although Scheiner did not recognize this, and consequently this did not hold as an uncontrovertable proof of the correctness of the Copernican theory. Nevertheless it cannot be denied that this argument served to weaken the opponents of Copernicus fully as much as many of the other arguments which had been advanced by Galileo.

The second book of the *Rosa Ursina* is devoted to a description of the methods of observation and the instruments that were used by Scheiner. We are told that the period of observation extended over 16 years, and that observations were not only made daily, but that Scheiner was accustomed to observe frequently as many as 10, 20 or more times in one day in order to make a comparison with previous observations or to correct possible errors. It was this painstaking method that, as we shall see, acquainted Scheiner with the manifold changes and transformations which normally take place during the development of the sun-spots and faculae, which he describes in such detail. Evidently by the time that the *Rosa Ursina* was ready for publication, Scheiner had learned that for him at any rate, intuitive reasoning was not safe, for he tells us many times during the course of the book that he does not wish to make a definite statement on this or that point, as there is not sufficient observational data available. This conservatism fortunately not only necessitated his making as many observations as possible, but also showed him the advantage to be gained by varying the methods of observation, in order better to determine the reality of that which he wished to establish.

As we have seen, Scheiner's first observations were made when the sun was near the horizon or was partially obscured by clouds. At the suggestion of Cysat he constructed a telescope in which the lenses were ground from colored glass, with this the sun could be observed at any altitude. This instrument he called "Helioscope," and owing to its

PLATE XVIII.


PAVLVS IORDANVS II VRSINVS BRACCIANI DVX

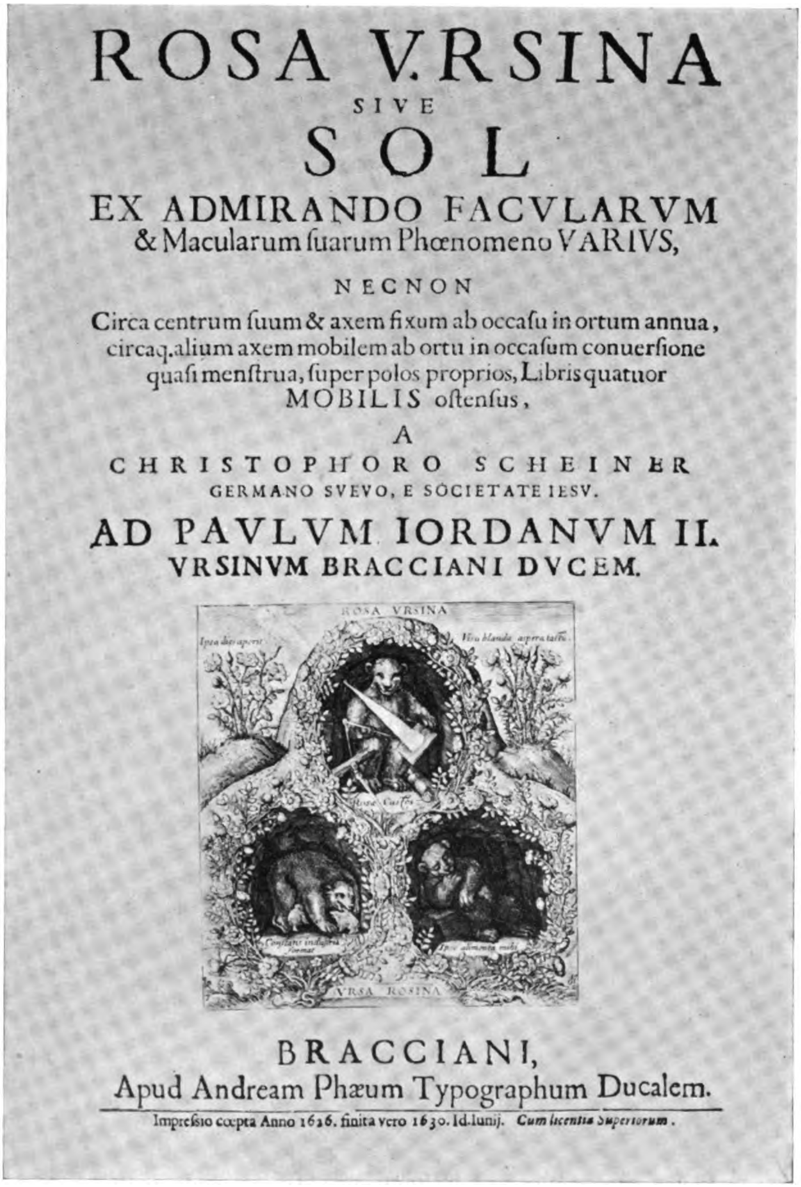
SOL TIBI SIGNA
DABIT.
Virg. 1. Georg.

VRSINAE Dux Gentis Aue; Tibi plaudit Olympus;
Currit in obſequium Phœbus & Vrſa tuum.
Signa genusq. ſuum mutis incidere ſaxis
Si potuere alij, Fors ea magna fuit.
SIGNA Genusq. tuum Cæleſtibus indita fulgent
Orbibus; VRSINOS fixit in axe Deus.
Macte animi virtute Heros, genus Alte. Trophæis
Quod nimis arcta tuis eſt humus aſtra petis.
MOECENATI Auctor.

Sol quoque & exoriens & cum ſe condet in vndas
SIGNA dabit. Solem certiſsima SIGNA ſequuntur,
Et quæ mane refert, & quæ ſurgentibus aſtris;
(Quando) naſcentem MACVLIS variauerit ortum.
Virg. lib. 1. Georg.

Rosa Ursina, DEDICATION TO PAULUS JORDANUS II.

PLATE XIX.



ROSA VRSINA
SIVE
SOL
EX ADMIRANDO FACVLARVM
& Macularum ſuarum Phœnomeno VARIVS,
NECNON
Circa centrum ſuum & axem fixum ab occaſu in ortum annua,
circaq. alium axem mobilem ab ortu in occaſum conuerſione
quaſi menſtrua, ſuper polos proprios, Libris quatuor
MOBILIS oſtenſus,
A
CHRISTOPHORO SCHEINER
GERMANO SVEVO, E SOCIETATE IESV.
AD PAVLVM IORDANVM II.
VRSINVM BRACCIANI DVCEM.

BRACCIANI,
Apud Andream Phæum Typographum Ducalem.
Impreſsio cœpta Anno 1626. finita vero 1630. Id. Iunij. *Cum licentia Superiorum.*

REDUCED FAC-SIMILE, TITLE PAGE OF *Rosa Ursina.*

superiority, smaller details of spot structure and faculae could be seen. Scheiner describes the helioscope as follows:*

> The helioscope consists of at least two colored glasses, convex and concave, of good clear material, with sufficient color, containing neither bubbles nor sand particles, in particular free from veins, streaks, or waves. If, however, the two lenses are not sufficient to diminish the sun's light, one must add one or more pieces of colored glass, plane parallel, well ground and polished......all these glasses must be placed perpendicular to the axis of the telescope.

That Scheiner had many sad experiences with the opticians of the day, and that any slight advantage which a piece of apparatus might possess became an excuse for raising the price,—a "hold-up" method, which it seems was well known even in that day, is learned from his remarks. Although the construction of lenses from colored glass required no more skill than did the construction from white glass, one finds: †

> That the workmen immediately wished to profit through the desires of the purchaser, and raised the price unbelievably, on account of the advantage of the device, which the purchaser had discovered by himself and through his own industry.

In his earlier observations Scheiner employed the Galilean form of telescope with concave eye lens. Some years previously Kepler had advocated the use of a telescope with convex eye lens as possessing special advantages, particularly in increasing the available field of view. Kepler, it appears never made any practical use of this arrangement, but Scheiner perceived its advantages and at an early date (about 1613) constructed the first telescope of this pattern.

Scheiner mentions in many places in his book the confidence that he has in his telescopes. He describes in great detail the various kinds of lenses, with their combinations, and the advantages possessed by each when employed for solar observations. A clear homogeneous lens is to be treasured like a diamond. The performance of a telescope was judged: ‡

> From the size and definition of the image; under otherwise similar conditions the longer telescopes are better......It is to be noted, however, that the size of the field is in the inverse ratio to the magnification and the definition, so that with this arrangement the sun can only be observed gradually, a little at a time, which is no small advantage.

During his earlier observations Scheiner had perceived that when using the telescope in the ordinary manner, no really valuable results could be obtained, because with this method it was impracticable to determine the positions of the spots on the sun's surface, in order later to study the changes in the solar phenomena in position and time; which had been the object of his observations from the beginning. To avoid this difficulty he adopted the method of projection, and continued using it for practically all his observations. It is only by this method, Scheiner remarks, that the appearance and positions of the spots can be accurately portrayed on paper, and thus only can the true and apparent motions of the spots be made ready for interpretation in an accurate manner. Another very essential advantage was that:[*]

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* *Rosa Ursina*, p. 70.

† *Ibid.* p. 71.

‡ *Ibid.* p. 70.

> The observer gains such confidence in his manner of observing, and in the observations themselves, that every reason for doubt is removed.

Scheiner apparently began using this method as early as 1612.[†]

From the conviction that the observer can be sure of his observations only when he knows his instrument thoroughly, or, as we say, when he knows its "errors", Scheiner undertook a most careful investigation to determine whether the positions of the spots obtained by the method of projection actually agreed with their true positions. To do this, he invented a device, which he believed to be most efficient and hitherto unknown[‡] This device was used not only to establish the accuracy of the drawings but also for their measurement. He divided the circumference of a circle (smaller than the aperture of the telescope) drawn on a suitable card, into twelve parts, joining these points with straight lines in such a manner that there resulted a network of small squares formed by horizontal and vertical lines. The intersections of these lines with each other and with the circumference he punctured with a small needle; the card was then placed in front of the telescope objective. Directing the telescope toward the sun, the projected image showed small points of light which marked the position of each line. The punctures on the circumference were projected in a circle, but the straight lines, with the exception of the two diameters, were projected more or less curved. The displacements of these points could then be measured and later used to determine the corrections to be applied to the positions of the spots.

In order to observe successfully, the telescope must be provided with a suitable mounting capable of following the sun in its diurnal motion. This Scheiner originally accomplished by the construction of his "Machina Verticalis", which was essentially a form of alt-azimuth mounting. It was constructed somewhat as follows:[¶] A strong frame-

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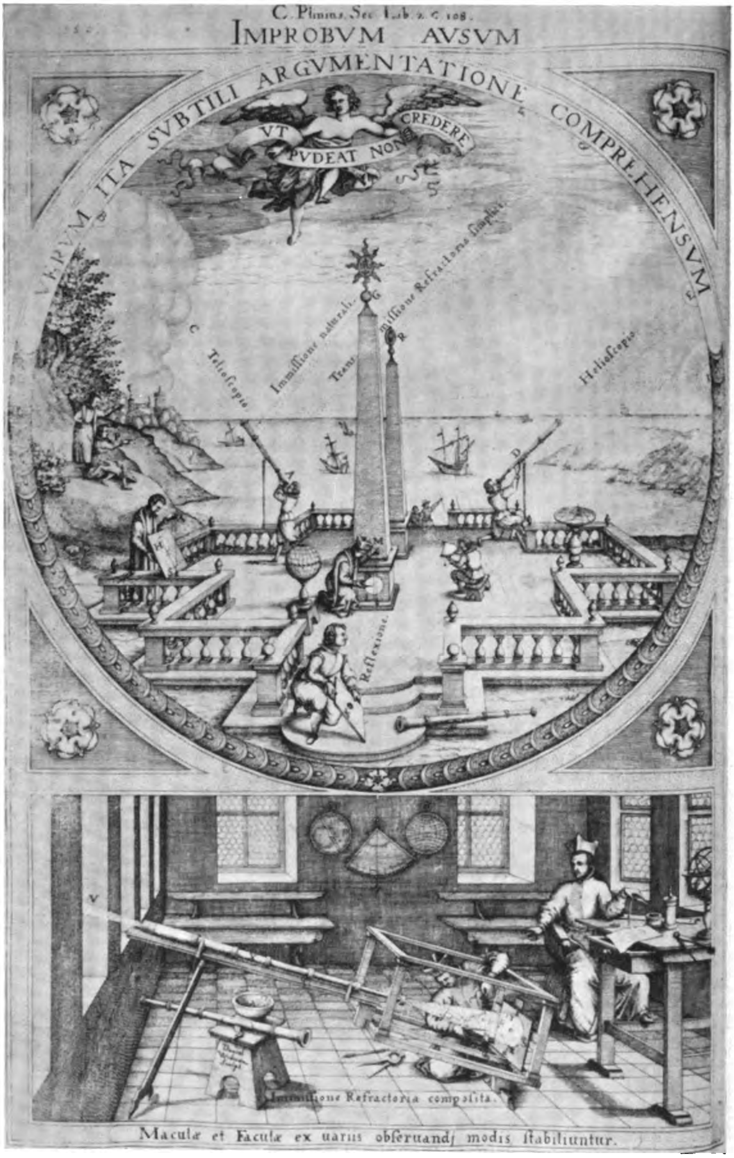
[*] *Ibid.* p. 75.

[†] *Ibid.* p. 152.

[‡] *Ibid.* p. 460.

[¶] *Ibid.* p. 152.

PLATE XX.


C. Plinius, Sec. Lib. 2. c. 108.
IMPROBVM AVSVM
VERVM ITA SVBTILI ARGVMENTATIONE COMPREHENSVM
VT PVDEAT NON CREDERE
C
Telioscopio
Immissione naturali
G
Transmissione Refractoria simplici
R
Helioscopio
A
D
M
Reflexione
V
Immissione Refractoria composita.
Maculæ et Faculæ ex uariis obseruandi modis stabiliuntur.

Full page illustration at Commencement of Book III, *Rosa Ursina.*

work was supported in such a manner that one end was free to slide upon a smooth base. At the other end of this framework the telescope was mounted, at the end over the slide was placed a board to carry the paper screen upon which the image was projected. The full-page illustration at the commencement of the third book shows this arrangement, with the addition of a structure surrounding the board enabling it to be covered with a dark cloth, thus shading it from extraneous light. (Plate XX).

The obstacles met with in the pursuit of the observations, which Scheiner calls the "thorns of the Ursinian Rose" are described in the most detailed manner; he calls attention to every circumstance which might affect the accuracy of the observations. Great importance was placed on the correct orientation of the image, without which a comparison of the positions of the spots at different times, and the accurate determination of the rotation elements would have been impossible. The orientation of the image was obtained by allowing the shadow of a vertical thread to fall across the projected image. The points of intersection of this shadow with the circumference of the image were noted, as was the time, from which the sun's altitude could be calculated. This procedure yielded the necessary data for determining the orientation, since there was thus obtained the intersection of the vertical circle through the sun's center with the circumference of the disk, and a short calculation gave the position of the ecliptic on the projected image.

If one recalls the state of astronomical knowledge in Scheiner's day, one can easily understand that he should have placed great importance on this device, and would only communicate it to his friends as a precious secret. Micrometrical apparatus was still wanting, and in particular was excluded from use with the Galilean telescope. At that time there was no other method for determining the positions and motions of the spots which combined such great simplicity with such accuracy.

In spite of the commendable results which Scheiner obtained with this method of observing, in consequence of his dexterity and skill, he frequently complains of the difficulties encountered in making exact observations, which were mainly the result of the alt-azimuth form of mounting. However, the happy elimination of these difficulties was accomplished by another member of the Jesuit Order, Christopher Grienberger of Rome, who will be remembered as one of the four members of the Commission apppointed to examine into Galileo's discoveries in 1611. Acting upon Grienberger's suggestion Scheiner constructed what might be called the ancestor of the present day equatorial telescope. Concerning it Scheiner remarks:*

> The (equatorially mounted) telescope can be directed toward the stars,......and when once directed toward the right parallel the telescope will always keep the star in the field of view. On this account the arrangement is very convenient for the day time observation of stars, since the position of the star can be found without fail, and Father Grienberger states that he had this particular thing in view while thinking upon this equatorial apparatus.

In the third book of the *Rosa Ursina* Scheiner gives a complete description of this instrument, "since it seems that the inventor has no desire to do so himself." The illustration in the *Rosa Ursina*† (Plate XXI) shows its essential characteristics. The instrument consisted of a polar axis of wood, provided with an hour circle; the telescope was mounted on this axis, the motion in declination, however, being limited to the extent of the zodiac. A scale of declinations was provided, but this was graduated with the signs of the zodiac instead of degrees. Barring the limited motion in declination, and the absence of a driving clock, this instrument was entirely similar in principle to our modern equatorials. Naturally Scheiner at once appreciated the advantages possessed by this instrument, and recognizing its convenience in observing and for following the sun's motion, called it "Heliotropii Telioscopici." He commenced using it on March 4th, 1627.‡ In addition to the convenience in following the motion of the sun, this mounting afforded the additional advantage of offering a much simpler and at the same time more accurate method of orientation of the drawings than did the earlier alt-azimuth mounting.

In addition to the description of the equatorial mounting, the third book of the *Rosa Ursina* contains the enormous mass of observational data obtained during the many years that Scheiner had devoted to the subject. It will be admitted by all, that none of Scheiner's contemporaries observed the sun's surface as industriously or as systematically. In order to obtain still more observational material he availed himself of the services of others who were associated with him in various ways. The foremost of these was Cysat, who was present at the time of the first observation, and afterwards succeeded Scheiner at Ingolstadt. After a time he added Father George Schönberger. To these two he communicated his valuable method of orienting the sun's image. Among the others who later assisted were Father Chrysostomus Gall, subsequently Professor of Mathematics at Lisbon; Father Giuseppi Biancani, Professor of Mathematics at Parma; Father Kasper Reuss, a missionary

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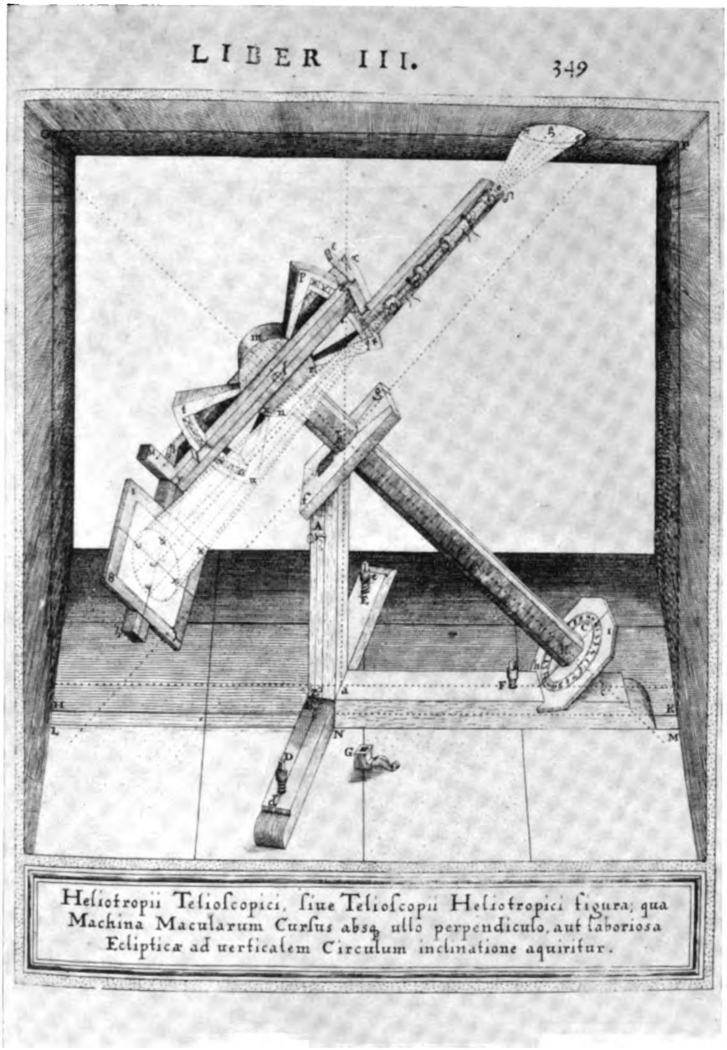
* *Ibid.* p. 352.

† *Ibid.* p. 349.

‡ *Ibid.* p. 336.

PLATE XXI.


A
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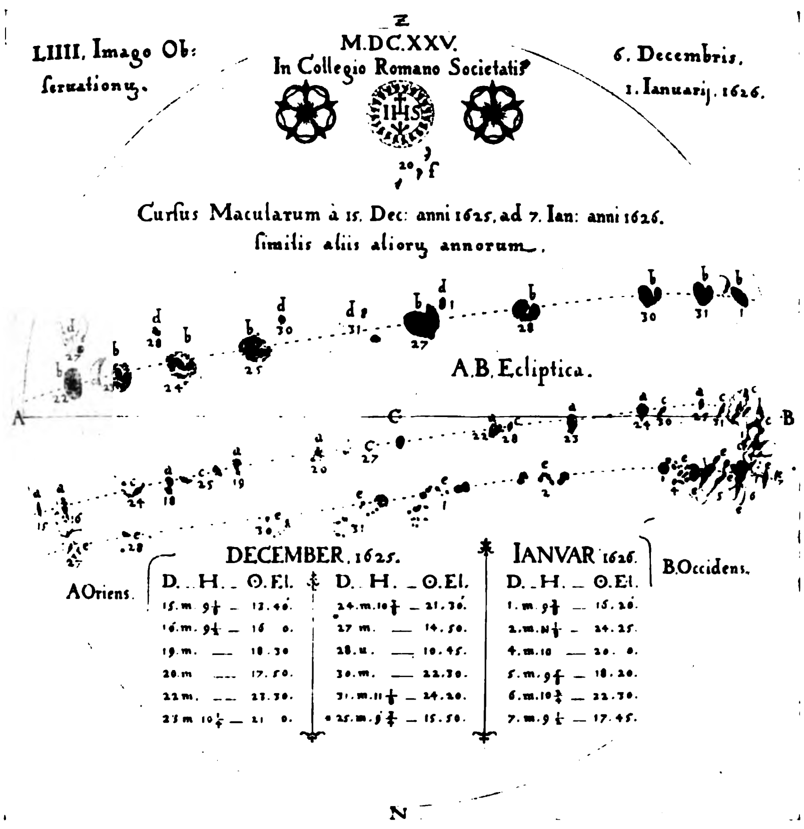
LIBER III. 349

Heliotropii Telioſcopici, ſiue Telioſcopii Heliotropici figura; qua
Machina Macularum Curſus absq; ullo perpendiculo, aut laboriosa
Eclipticæ ad uerticalem Circulum inclinatione aquiritur.

"Heliotropii Telioscopici."

PLATE XXII.



LIIII. Imago Obſervationũ.

M.DC.XXV.
In Collegio Romano Societatis

6. Decembris,
1. Ianuarij. 1626.

Curſus Macularum à 15. Dec: anni 1625. ad 7. Ian: anni 1626.
ſimilis aliis aliorũ annorum.

DECEMBER. 1625.						IANVAR 1626.		
D.	H.	☉.El.	D.	H.	☉.El.	D.	H.	☉.El.
15.m.	9½	13.40.	24.m.	10½	21.30.	1.m.	9½	15.20.
16.m.	9½	16 0.	27 m.	—	14.50.	2.m.	11½	24.25.
19.m.	—	18.30	28.m.	—	10.45.	4.m.	10	20. 0.
20.m	—	17.50.	30.m.	—	22.30.	5.m.	9⅔	18.20.
22 m.	—	23.30.	31.m.	11½	24.20.	6.m.	10¾	22.30.
23 m	10¼	21 0.	25.m.	9¾	15.50.	7.m.	9½	17.45.

FULL-PAGE DRAWING OF SUN, SHOWING SPOTS AND FACULAE.
REDUCED FROM *Rosa Ursina*.

to Peru. It is of interest to note that the Hollander, Karl Malapert while on a journey to Poland, sojourned for a time at Ingolstadt in order to become acquainted with the methods of observing. By such means it was possible for Scheiner to obtain many uninterrupted series of observations from at home and abroad, which were well adapted for studying the rotational movement of the sun. Scheiner utilized these observations, which were made at widely separated stations to ascertain if there were any evidence of parallax shown by the spots; the results, as might be supposed, were negative.

In the *Rosa Ursina*, Scheiner published a large portion of his sunspot observations, which were principally the observations made during his stay in Rome. Older observations, of equal importance, some of them made by Cysat, still remained at Niesse, from which place Scheiner had gone to Rome. But on account of wars and other dangers he dared not risk having them sent to him. As it is, there are seventy full page drawings of the sun (from December 1624 to June 1627), on each of which is shown the complete paths of various groups of spots and faculae during their period of visibility. The position of the ecliptic is shown on the drawings, as are the time of observation and the altitude of the sun. A mere glance at these drawings (see Plate XXII) is sufficient to show, to one familiar with the surface of the sun, the great accuracy and the conscientiousness shown by the portrayal of the smaller details. In 180 pages of the book is contained a very detailed journal of the observations describing the phenomena depicted in the drawings.

The fourth book contains a discussion of the results derived from the mass of observational data included in the third book,—the description of the phenomena of the sun's surface, and the theory of the spots and their motions. In an earlier part of his book, Scheiner had described the general appearance of the sun's surface as follows:*

> If one uses a helioscope of excellent quality, one sees in addition to these [the spots and faculae] the following unknown and hitherto unpublished phenomena: 1. That the entire surface of the visible hemisphere is varied, composed of shaded regions and points of light (luculae). 2. That the entire surface resembles a ruffled sea, and that this appearance continually changes.

Both Schreiber† and Carrara‡ assert that in the *Rosa Ursina* is given the first description of the phenomenon of the sun's surface known as the "granulation." This is believed to be an error. Galileo indicated in a letter to Gio. Battista Baliani, dated March 12, 1614, that he had already observed this phenomenon. After stating his ignorance concerning the materials of which the sun-spots are composed, he writes:*

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* *Ibid.* p. 71.

† *Op. Cit.* p. 78.

‡ *Op. Cit.* **24**, 91.

> It seems to me that I observe that all of the face of the sun is, so to speak, of heterogeneous light, that is, as if it were surrounded by a delicate cloud of unequal transparency.

This unquestionably refers to the granulation; and hence this was evidently first seen by Galileo, although Scheiner later described it more carefully and with greater detail.

Scheiner also described at some length certain phenomena of the sun's surface which leads one to believe that he had observed the so-called "veiled spots", to which Trouvelot called attention† in 1876. These Scheiner describes as follows:‡

> There are shadows or secondary spots, points of light (luculae) or secondary faculae, and regions of uniform brightness......The duration of the individual shadows [veiled spots] and luculae, as well as of the uniform regions is short and very variable. For many shadows [veiled spots] endure for scarcely a day, not even for an hour, as can frequently be observed, for I have often devoted many hours exclusively to these observations.......I call these shadows "secondary spots" chiefly on account of their duration and faintness......for these secondary spots are not real spots, as compared to the true spots, but with respect to the true spots are like a shadow to a solid body. In regard to size, appearance, position, faintness or darkness, and to total number these show a great difference. In the neighborhood of the pole they are very rarely noticed, in the spots zones they are very thin and faint, between these two regions they are numerous and prominent. They are seldom seen unaccompanied by luculae, which sometimes precede them, sometimes follow them, and are seen sometimes to the north or to the south, while sometimes they appear alone in the midst of a uniform region.

Scheiner considered the observations of the secondary spots and of the granulation to be of the greatest importance, also the most difficult of all the observations to accomplish satisfactorily. Notwithstanding this difficulty he devoted considerable time to it. He states:¶

> The secondary spots give the solar surface an appearance like a shining white cloth that has been covered with a cobweb, or like a piece of very clean paper that has been moistened, or like a well polished mirror that has been touched with the hand or breathed upon.

In another place he remarks:||

> That which has been remarked for the secondary spots, holds similarly for the luculae, for they both are continually changing and present an almost incredible

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* *Gal. Op.* **12**, 34.

† *American Journal of Science*, (3), **11**, 165.

‡ *Rosa Ursina*, pp. 344-346.

¶ *Rosa Ursina*, p. 157.

|| *Ibid.* p. 346.

> **transformation from one day to the next. One imagines the surface of a tranquil lake, or of a quiet sea disturbed by a gentle breeze and illuminated by the sun. The rippling presents a continual change of light and shade to the eye, as the sun's rays are reflected more or less. The same impression made by the rippled surface of the water is recalled by the above described appearance of the sun's surface.**

It is evident from these quotations that Scheiner believed that the changes visible in the granulation actually took place as he observed them, and that the surface of the sun "rippled like a quiet lake." That such changes do take place is well known through the recent investigations of Hansky and Chevalier, but these could not have been observed by Scheiner. What he believed to be the real motions of the luculae were no doubt largely the effect of the disturbances in the atmosphere which produce the well known "boiling" effect.

The numerous observations which Scheiner made during so many years of patient industry naturally showed him the falsity of his former belief that the spots were of the nature of planetary bodies. How long Scheiner retained this belief is not known; at all events, the first acknowledgement that the spots were a part of the sun is in the *Rosa Ursina* (Lib. I). Galileo had recognized this soon after his first observations, although convincing proofs were not given until later, and explained the motion of the spots as caused by the sun's rotation. It is rather curious that Schreiber* will not give Galileo credit for ascertaining the true nature of the spots; he regards his conclusions as the fortuitous outcome of the intuition of a genius rather than a scientific result deduced from a series of carefully made observations. Schreiber considers it of greatest importance in judging the quarrel between Scheiner and Galileo, to remember that Galileo was unacquainted with the methods of determining the positions of the spots which had been developed by the Jesuit. The latter, it appears, laid little stress upon the question of who first saw the spots, but claimed credit because he had made the first scientifically valuable observations. But if we recall Scheiner's discussion of these "scientifically valuable" observations, and the erroneous conclusions that he drew from them, the laurel wreath will still be awarded to Galileo. Scheiner asserts in the preface to his *Rosa Ursina*† that during the years 1611 to 1617, no one but himself and his co-laborers at Ingolstadt knew how to make accurate sun-spot observations, and from such observations only could trustworthy conclusions be drawn. This is no doubt quite correct, but unfortunately Scheiner, although possessing the knowledge of a method of accurate observation, did not at that time know how to interpret his results correctly. In denying credit to Galileo, Schreiber asserts that up to the time when Galileo had made the first announcement of his belief in the solar nature of the spots and consequent rotation of the sun, he had not had sufficient opportunity to make a series of observations such as would be required for a conclusive demonstration of the published result. Schreiber also objects, because, since Galileo's observations were not made with sufficient care and accuracy to reveal the inclination of the sun's axis and the curvature of the spot paths, nothing else could have been deduced from them, and, hence, the correct theory of the spots announced by Galileo ought to be regarded as nothing more than a sort of happy guess, and not as a scientific result! Which, when one recalls the arguments in the letters to Welser, is a very peculiar view to take.

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* *Op. Cit.* p. 84.

† *Ad Lectorem.*

After Scheiner had persuaded himself that the spots must be adherent to the surface of the "rose of the Ursini," he pursued the subject with energy, and deduced proofs from his own observations. Concerning the solar nature of the spots as shown by their rotation, he writes:*

> 1. If the true, not the apparent motion shown by the solar phenomena is inherently regular, and if this regularity is conceded to it by the astronomers because of the apparent motion, and as a common sense interpretation of the observations; then this regularity is only possible if the spots are placed on the sun......2. If the spots are placed on the sun, then their true and peculiar movement is always shown as regular.......3. If the spots are distant from the surface of the sun, then their true motion will never appear regular, but always as irregular and in contradiction to the apparent motion of the spots.

Galileo had announced as early as June 1612† that the regions in which the spots are found are limited to two zones on each side of the sun's equator. In the *Rosa Ursina*, Scheiner mentions these regions as follows:‡

> That region of the sun in which the primary spots are seen and describe their paths......extends from both sides of the ecliptic (*sic*) toward the pole. Although one cannot fix a definite limit to this region, it appears, from observations made through many years, to extend not more than 30° toward the pole; but with respect to the faculae and the secondary spots the region sometimes reaches the pole.

Scheiner divides the remaining portions of each hemisphere into two zones, a truly polar zone and an intermediary zone. Concerning the phenomena visible in these three zones he remarks:

> The sun generally appears quiet in the polar zone, somewhat more active in the neighboring zone, and full of changes and mighty disturbances in the spot zone; although it can happen that the whole surface shines uniformly bright and illuminates us.

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* *Rosa Ursina*, p. 479, et seq.

† In the letter to Guiliano de' Medici; *Gal. Op.* **11**, 334.

‡ *Rosa Ursina* p. 568.

Scheiner gave considerable attention to the causes of, and the varying degrees of darkness shown by different spot nuclei. That he believed that the effect of contrast was for a large part responsible for the appearance of the spots is indicated. He writes:*

> Daily experience shows that objects of no great brightness, when between or near others which are very bright, cannot be clearly distinguished, and appear like shadows to our eyes.

Concerning the spots:

> The degree of darkness is very different, many are coal black, others are somewhat lighter or ash grey.
>
> What wonder is it if we see these bodies on the sun only in the color of shadows......The truly black masses, however, I call the nucleus of the spot, for it is usually found in the middle of the spot.

Regarding the causes of the darkness, Scheiner conceived of two possibilities, either of which might give rise to this phenomenon; namely, an increase in the density, or an increase in the quantity of the material which formed the spot.† That increase in density alone could bring about the effect he considered as somewhat uncertain, for, as he argued, this could not change the color of the nucleus. As an illustration he mentions our atmosphere which is denser in winter and yet is actually more transparent.‡ On the other hand the observations offer no evidence of increase of material. If the spots become darker on this account, they must needs also increase in size from all directions. Conformably, the nucleus should grow fainter as the spots grow smaller. In addition may be mentioned the fact that the spots are darker in the center and brighter at the edges, a proof of the greater quantity of material at the center; if this were not so, the light would penetrate the center of the spots as it does the surrounding penumbra. In fact the phenomenon appears much more to favor some other physical cause than increase of similar material.

Scheiner then returns to the increase in density hypothesis, and reasons as follows: The nuclei are evidently not much below the level of their surroundings, for they can still be seen when entering and disappearing from the disk, but they are still sufficiently opaque to obstruct the passage of light more than the rest of the spot. If the dark nucleus is caused by the addition of material, the surrounding regions should become at least relatively darker, and the boundary between the nucleus and the penumbra would become relatively indistinct, which does not occur. On the other hand it must not be assumed that the nucleus increases from underneath to the same degree that the darkness increases. All this strongly favors the hypothesis of condensation or increase in density. This is further strengthened by the appearance of the nuclei of the small spots which are sometimes darker than those of other spots having larger area; it is also to be noted that these little spots last longer. Moreover the bright regions between the spots (bridges?) frequently consume the material surrounding the nucleus, which is not disturbed in any way; indicating a great difference between the nucleus and its surroundings.

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* *Ibid.* p. 497 et seq.
† *Ibid.* p. 503 et seq.
‡ Scheiner's knowledge of meteorology was evidently deficient!

(To be continued.)

DISCOVERY OF EIGHT VARIABLE STELLAR SPECTRA.*

HARLOW SHAPLEY.

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In three earlier communications to the Proceedings various phases of the problem of Cepheid variation have been considered.† No further introduction to the present note is necessary beyond the statement that the periodic change in color, which appears to be typical of all Cepheids, has already been found to correspond to normal changes of spectral class for two cluster-type stars, RS Boötis and RR Lyrae, and for one variable of longer period, δ Cephei. In order to test to what extent the inconstancy of spectrum is a general phenomenon of Cepheids, some 150 spectrograms of representative variables of this class have been made with the 10-inch portrait lens and objective prism. The periods of the stars investigated range from 9 hours to 27 days; many are Cepheids for which spectroscopic orbits have been computed; some are well-known naked eye variables, others are much fainter stars; for some changes in color have been suspected from studies of the light curves, for others the maximum intensity of the spectrum has been observed to shift toward the blue upon the approach to maximum light. For none, however, has it been suggested, so far as the writer knows, that the spectrum changes periodically along the normal spectral series.

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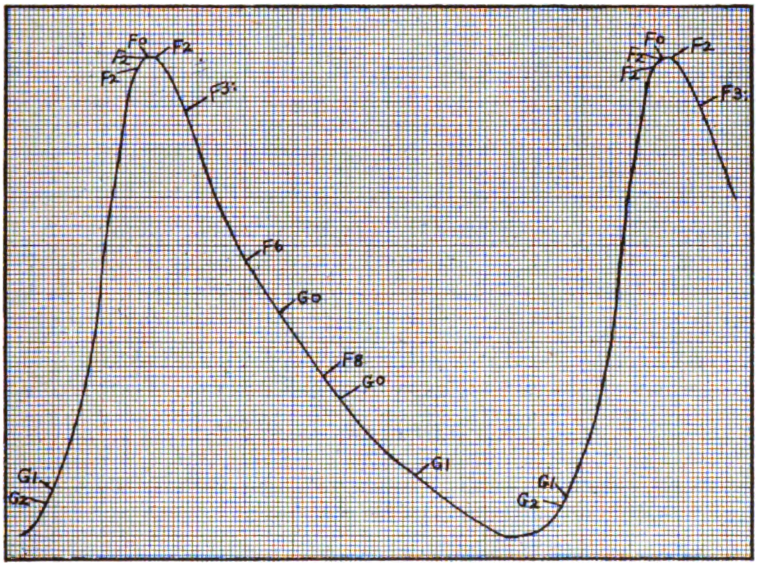
* Reprinted from the Proceedings of the N. A. S., for April 1916.

† Shapley and Shapley, 1, 452, 1915.
Shapley, 2, 132, 1915.
Adams and Shapley, 2, 136, 1916.

Following the numerical method of classification recently described by Adams,* the change of spectrum of the F-type and G-type Cepheids is susceptible to easy detection, even when the variation is very small. For example, in the work with low-dispersion on F-type spectra the relative intensity of the G band and the hydrogen line $H\gamma$ is particularly capable of showing small changes of type. The results can be summarized briefly.



THE LIGHT CURVE OF δ CEPHEI AND THE VARIATION OF SPECTRAL TYPE.

The accompanying figure contains a curve showing the spectrum variation for δ Cephei, exhibiting the conspicuous change, from maximum to minimum light, in the nature of the spectral lines. The detailed appearance with high dispersion of a small section of the spectrum has been shown in an earlier communication by Adams and Shapley. The table contains data relative to the spectra of eleven Cepheids, (all that are now known to vary in spectrum) and some information concerning their light variations. The observed range of spectrum variation is in nearly every case smaller than the total range, as observations at the exact times of maximum and minimum light were not made. All the variables for which the present test was sufficient were found to vary in spectrum. It appears safe to infer, therefore, that all the Cepheids (including the cluster-type), besides being variables in light and in velocity, vary periodically in spectral class as well.

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* These PROCEEDINGS, 2, 143, 1916.

ELEVEN CEPHEIDS WITH VARIABLE SPECTRA.

Star	Maximum Magnitude	Range of Variation	Period	Number of Spectrograms	Observed Spectrum Variation
		Mag.	Days		
TU Cassiopeiae	7.3	1.1	2.139	9	F0 to F6
SU Cassiopeiae	5.9	0.4	1.950	19	A8 to F5
SZ Tauri	7.2	0.5	3.148	11	F4 to G2
T Monocerotis	6.0	0.8	27.012	6	F4 to F6
RT Aurigae	5.0	0.9	3.728	12	A8 to G0
W Geminorum	6.4	1.3	7.916	10	F3 to G0
RS Boötis	8.9	1.1	0.377	13	B8 to F0
X Sagittarii	4.4	0.6	7.012	5	F2 to G
Y Ophiuchi	6.2	0.8	17.121	4	F5 to G0
RR Lyrae	6.8	0.9	0.567	17	B9 to F2
δ Cephei	3.5	0.8	5.366	21	F2 to G3

STELLAR MAGNITUDES AND LIGHT RATIOS.

LOUIS BELL.

The translation of stellar magnitudes into light ratios and vice versa is one of the matters which frequently has to be dealt with in the photometric work which falls to the lot of the professional or amateur astronomer. As everybody knows, the relation between magnitude and light is a very simple one. A star of magnitude M gives 2.512 times as much light as a star of the magnitude M+1; or the star of M+1 gives 39.8% of the light received from the star of magnitude M. The light ratio and its inverse, the per cent relation, are ordinarily obtained with a logarithm table or, in observatories where the work is frequent, from a tabulation of the ratios, direct or inverse, belonging to each small difference of magnitude.

Having had considerable occasion to use in ordinary photometric work a photometric wedge graduated in stellar magnitudes, from which the light ratios had to be obtained, the writer turned to his slide rule and found readily the following method of making the computations, not in the least difficult, but rather outside the scope of the usual instruction book on the slide rule. For the simple geometric ratio of 2.512 per magnitude probably the easiest scheme of using the ordinary Mannheim slide rule, which has a cm scale along the unbevelled edge, is as follows:

Bring the fiducial mark on the runner down over its side by the careful use of a steel square, which enables one to take readings of the fiducial line on the cm scale. Then set the slide 1 cm to the left, so that its right hand index stands at 25 cm instead of 26, which is its usual position. Now taking each 5 cm as 1 stellar magnitude, one can read directly from the cm scale, which is actually divided to mm, the corresponding light ratios on scale B of the slide or the reverse. The graduation gives direct reading to .02 magnitude. In this way the ratios can be read quickly and accurately over a range of 5 magnitudes. Five magnitudes gives the ratio of 1 to 100, and the ratios beyond this magnitude difference go on repeating in an obvious manner.

If closer reading over a moderate range is desirable, as in looking into the light ratios of variables, take 10 cm per magnitude on the cm scale and read on scale C on the slide. This gives direct readings over a range of 2.5 magnitudes to hundredths of a magnitude. The inverse ratios can, of course, be obtained singly by taking the reciprocals in the ordinary way, but if it is desired to run them off directly it is only necessary to turn over the slide, setting the end indices in coincidence with those on the scales. The scale of equal parts in the center of the slide used for the purpose of reading off logarithms of numbers, then reads from right to left. Each of the numbered divisions is sub-divided into 50 parts and if one counts two of the numbered divisions per magnitude he has a scale extending over 5 magnitudes divided into hundredths, each small division on this scale being .5 mm. It is then only necessary to set off on this scale of equal parts the magnitudes to hundredths and to read the inverse ratio directly over scale A, (or counting 4 divisions per magnitude, on scale D). For instance, a setting at 2 on the scale of equal parts gives 39.8% for 1 magnitude, 15.8 for 2 magnitudes, and so on through the integral or fractional magnitudes up to 5. With the slide reversed in this way one can also read the direct ratios, just as from the cm scale with the slide displaced, but one has to read the scale on the slide either backwards or up side down in this case, which is rather less convenient than the scheme already described. This is really a very simple use of the facilities extended by the slide rule, but it is not immediately obvious, and the writer has found it a great convenience in reducing the readings on a photometer graduated in stellar magnitudes.

THE COSMOLOGICAL IDEAS OF THE GREEKS.

HECTOR MACPHERSON, M. A., F. R. A. S.

(I) The Speculative Period.

To the ancient Greeks belongs the honour of separating for the first time cosmology from theology. Just as the genius of the Hebrew people was religious, that of the Hellenes was in the direction of philosophy and art. And just as the Hebrews developed the religious view of the world, it fell to the Greeks to develop the philosophic view. As Eucken remarks—"Philosophy which in the case of the Greeks does not start from man and the problem of his happiness but from the Universe as a whole, aims to comprehend the world in a natural way by means of its own interconnections; it seeks for an immutable substance or for fixed quantitative relations. It is forced to discard the first impression of things and to destroy their visible image; but with a sure instinct for the essential it reconstructs the world in outlines whose simplicity bears the marks of genius and excites our perpetual wonder."

Nevertheless Greek cosmological speculation had its origin in the mythological age, and was at first similar to the mythologies of Babylon and other ancient lands. In the poems of Homer and Hesiod we meet with earlier Greek cosmological ideas; and in them cosmology and theology are, as in the Babylonian world-concept, inextricably connected.

Both Homer and Hesiod, in their poems, give us an idea of the world-view of the primitive Greeks. In Homer, the Earth is a flat circular disc, surrounded on all sides by the great river Okeanos. This mighty river commenced north of the Pillars of Heracles, and wound its way north, east and south of the Earth. The disc of the Earth is supposed to be partly covered with the sea. South-west of the River Okeanos is the land of the Cimmerians; and, in some places, Homer indicates that adjacent to the Cimmerian land is Erebus or the land of the shades; in other passages, however, Homer places Hades beneath the surface of the Earth.

Above the Earth is the region of the ether; and still higher is the vault of the heaven. Beneath this vault the Sun, Moon and stars perform their motions, rising out of Okeanos in the morning and returning thither at night. The Hesiodic conception is somewhat similar. Hesiod places Tarturus, "the depth", as far below the Earth as the height of heaven is above. Thus the whole Universe is represented as a sphere.

And this sphere is divided into two halves by the earth's surface. This conception is somewhat akin to that of the Hebrews, as brought out by Schiaparelli. In his "Theogony" Hesiod puts forth his cosmogonic views. How far this work is the product of purely Hellenic thought is uncertain. Pfleiderer considers that the work "in many instances disarranged popular legends with foreign Asiatic speculation." In the beginning was Chaos, from which sprang the Earth-goddess, Gaia, the mother of all. Then follow Erebus and Aether, and these are followed by the production of Uranos, the god of the heaven, and from the union of the god of heaven and Gaia, the goddess of earth, there springs the race of gods and titans—personifications for the most part of natural forces. The only important point about the theogony is the fact that the Earth sprang from Chaos, and from the union of Earth and Heaven the other personified natural forces were produced.

What Hesiod actually meant by Chaos is uncertain. Plutarch believed it to be water; and in one or two places, Homer speaks of Okeanos as the origin of everything. Here we have the connection of Greek and Babylonian mythology as Dr. Dreyer notes "the connecting link between the primitive popular notions and the first attempt at philosophical enquiry."

This first attempt was due to Thales of Miletus, the first Greek philosopher. It is true that his idea of the constitution of the world was as primitive and, in the light of later knowledge, as absurd as those of Homer and Hesiod. The Earth, he believed, was a circular disc floating like a piece of wood on the ocean; and in water Thales found the ultimate principles or substance of the world. At first sight, Thales may appear to have advanced but little beyond the standpoint of the poets; but there is one essential difference between his explanation of the world and theirs. Thales separated cosmological from religious speculation. In his explanation of the Universe, there was no mythological element. No gods or godesses were invoked—as in the cosmology of Hesiod and in the Creation Epic of the Babylonians. Aristotle discussing Thales' belief in water as the "first principle" suggests that the Milesian philosopher got the idea "because he saw that the nourishment of all beings is moist and that heat itself is generated from moisture, and persists in it (for that from which all things spring is the first principle of them) and getting this idea also from the fact that the germs of all beings are of a moist nature." Thales, at all events, has the distinction of being the first scientific philosopher.

Anaximander, the second philosopher of the Ionian School, abandoned the view of Thales. He found the first principle not in water nor in any other substance, but in the infinite (*το ἀπειρον*) or the indefinite.

This, says Schwegel, "was not something immaterial, but was probably conceived by Anaximander as primal matter not yet sundered into its individual elements." Out of this are all things developed and into it all things return. This conception of the origin of things was a remarkable one, and the sagacity of Anaximander's cosmogony is a strange contrast to the crudity of his world-view. He believed the earth to be flat or convex on the surface and to be in equilibrium in the center of the world. The heavens, he considered, were of the nature of fire and spherical in form. The heavenly bodies were thought to be placed at different distances—the Sun being more distant than the fixed stars. He had a curious explanation of the nature of the heavenly bodies. The Sun was a hole in a great ring through which the inhabitants of the Earth got a view of the fire which filled the rim of the ring, while the Moon and stars were similarly explained.

Anaximenes, the third of the Ionian philosophers, was if anything less advanced than the second. He found the "first principle" in air out of which all things were formed by compression or rarefaction; thus the Earth was produced from dense air. Anaximenes believed the Earth to be flat and the Sun, Moon and planets to be also flat bodies, while he supposed the stars to be attached like nails to a solid vault.

The Ionian School did not advance very far in the explanation of the world. At the other end of the Greek world, however, another school of thinkers—the Eleatics—had arisen and they developed more advanced views. Xenophanes, the founder of the school, it is true, did not advance beyond the Ionian standpoint. The Earth he believed to be flat and "rooted in the infinite," while the Sun, comets and stars were supposed to be fiery clouds. The Sun and stars were formed daily from fiery particles while the Moon was a compressed cloud which shone by inherent light and was extinguished monthly. Parmenides, the virtual founder of the Eleatic school, was a much more profound thinker. To him belongs the distinction of perceiving the spherical form of the Earth—a great advance in thought; he considered the entire universe to consist of a number of concentric layers encircling the stationary earth. This is the first time, as Dr. Dreyer observes, that we meet with the conception of concentric spheres. Parmenides also noticed that the Moon appears "always gazing earnestly towards the rays of the Sun and he drew the correct deduction that it shines by reflected light. He considered the Sun and Moon to consist of materials detached from the Milky Way, and the stars to be nearer to the Earth than the Sun, an error similar to that of Anaximander.

Curiously enough Heracleitus of Ephesus, who was a thinker at least as profound as Parmenides was much less happy in his cosmological speculations. Heracleitus found the explanation of the world in universal flux,—"Becoming" "All things flow" (πανιὰ ῥει). Accordingly he was led to consider fire to be the "first principle" of the world. There is, he taught, an unending circulation in nature "upward, downward, the way is one and the same." Accordingly it was in keeping with the doctrine of flux to revert to the idea of a flat earth. The Sun he believed to be formed of moist exhalations caught in a hollow basin with its cavity facing the Earth. The orb of day was ignited every morning and extinguished every night. On the whole Heracleitus' cosmological speculations marked not an advance but a retrogression in thought. Indeed the marvellous intuition of Parmenides seems to have been completely overlooked. Such illustrious thinkers as Anaxagoras, Empedocles Leucippus and Democritus erred fundamentally in regard to the shape of the Earth.

Anaxagoras believed that mind (νους) had produced the world out of the original chaos—the most profound idea of the ultimate cause of the Universe put forward before Plato and Aristotle. Mind formed the world by starting a rotatory movement, by which the present state of things was produced. Matter was thus separated into two halves, ether and air. The air—cold, dark, and heavy—was agglomerated in the centre, and from this was produced water from which again Earth appeared. The Earth was considered to be flat, and the Sun and Moon were supposed to be composed of similar matter—a considerable advance in thought. Anaxagoras also held the somewhat absurd view that the Milky Way represented the shadow of the Earth.

Empedocles,—working from his idea of four primary elements fire, air, water and earth, swayed to and fro by love and hate, attraction and repulsion—believed the Universe to be spherical and the earth to be flat. The Moon he considered to be air rolled together and mixed with fire and illuminated by the rays of the Sun, which was itself "a reflection of the fire surrounding the Earth."

Leucippus and Democritus were the first exponents, in rudimentary fashion no doubt, of scientific materialism. Leucippus believed matter to consist of an infinite number of atoms, very small and indivisible, by the union and separation of which the world is caused. Democritus believed that as a result of collisions among the atoms themselves a vortex motion resulted. Thus an infinite number of worlds is formed and thus the Earth originated. The Earth, according to Leucippus, is flat on the surface with an elevated rim. Democritus considered the Earth on the other hand to be a *discus*, higher at the circumference and lower in the middle. The Sun and Moon were considered to be large and solid masses. In regard to the Moon and to the Milky Way, Democritus held views in advance of his time. He believed the lunar markings to be due to the shadows of mountains and valleys; and he propounded the view that the Milky Way was an appearance due to the combined light of many faint stars.

More influential than the Ionian or the Eleatic Schools or than the followers of Heracleitus and Democritus was the famous Pythagorean Brotherhood. The philosophical school of Pythagoras was not only devoted to science and philosophy; it was also a religious society and a political organization. Hence it occupies a somewhat unique place in the history of Greek thought.

The underlying idea of Pythagoras was that the explanation of everything is to be sought in number. In the clear words of Dr. Dreyer, Pythagoras believed "that number not merely represents the relations of the phenomena to each other but is the substance of things, the cause of every phenomenon of nature. Pythagoras and his followers were led to this assumption by perceiving how everything in nature is governed by numerical relations, how the celestial motions are performed with regularity and how the harmony of musical sounds depends on regular intervals the numerical valuation of which they were the first to determine." Amid a great deal of fantastic speculation, Pythagoras seems to have got hold of various aspects of truth. To him, the universe was a sphere; and at its centre was the Earth, also of a spherical figure. This view, held by Parmenides alone outside of the Pythagorean School, was now accepted by the disciples of the founder.

The Pythagoreans latterly advanced beyond their master's cosmological standpoint. Philolaus taught that the apparent rotation of the starry sphere and the motion of the Sun around the Earth are caused by the movement of the earth in twenty-four hours round the circumference of a circle. This idea incorrect though it was marks a real advance in scientific thought. Philolaus went a step further. He considered that the Earth could not be the center of the Universe, but that the earth and the other celestial bodies moved round the "Central Fire" or the "Hearth of the Universe." This body, Philolaus and his followers held to be invisible from Greece and only to be seen in the regions beyond India. This doctrine called forth the ridicule of Aristotle. "They forcibly make" he said "the phenomena fit their opinions and preconceived notions and attempt to construct the Universe."

In many ways the Pythagoreans deserved the ridicule of the great philosopher. For instance as ten was supposed to be a perfect number, it was necessary to assume the existence of ten celestial bodies. Only nine were known—the earth, the Sun, the Moon, the five planets and the sphere of the fixed stars. Therefore the Pythagoreans imagined the existence of another body—the "antichthon" or "counter-earth" perpetually invisible from the inhabited side of our planet's surface.

Yet with all their errors the Pythagorean School under Philolaus took a remarkable step. They boldly declared that the chief place in the Universe was not occupied by our world. Hicetas of Syracuse seems to have gone still further and anticipated, partially, the Copernican system. Cicero writing long afterwards said that "Hicetas of Syracuse, according to Theophrastus, believes that the heavens, the Sun, Moon, stars and all heavenly bodies, are standing still and that nothing in the universe is moving except the earth, which while it turns and twists itself with the greatest velocity round its axis, produces all the same phenomena, as if the heavens were moved and the Earth were standing still." Opposition was developed within the Pythagorian School not only to this notion but also to that of Philolaus. Both Philolaus and Hicetas were in advance of their time and their views were destined to meet with but little approval.

In one particular the Pythagorean School did not teach in vain. The doctrine of the spherical form of the Earth was never again seriously challenged by intelligent men. The Pythagorean school had in itself a wide influence, but it exerted a still wider influence through the greatest of ancient philosophers, and one of the greatest minds of all ages—Plato. On the whole Plato had little interest in natural science. He had inherited from his master Socrates his somewhat contemptuous attitude to the observational study of nature. According to Xenophon, Socrates considered a knowledge of astronomy useful in so far as it enabled determinations of the days and hours to be made; but such questions as the orbits and distances of planets and stars and the causes of their revolutions, he considered to be a waste of time. Plato, like his master Socrates, was neither an astronomer, nor a mathematician nor a physicist. Nevertheless he was destined on account of his far-reaching influence to have a profound effect on cosmological thought. In the *Timaeus*, Plato explains that the Deity made the Universe and that he made it of a spherical shape, with one motion, that of rotation on its axis. After his exposition of his ideas regarding the "soul of the Universe," Plato explains that God resolved to form a movable image of eternity on the principle of numbers, which is time. "With this design the Deity created the Sun, Moon and the five other stars which are called planets, to fix and maintain the numbers of time." A good deal of controversy has raged over certain obscure passages. Some scholars consider that Plato believed in the rotation of the Earth about its axis and that he was actually a follower of Philolaus. But on the whole the balance of evidence is against the contention that he held such views. There seems no reason to doubt that he believed the Earth to be the centre of the Universe, a sphere suspended in space, fixed and immovable at the center of creation.

In regard to the heavenly bodies, Plato considered that the stars, chiefly formed of fire, move through the ether, a particularly pure form of air, which reaches from the limit of the terrestrial atmosphere into the starry spaces. The moon he believed to be the nearest body to the Earth; and in virtue of its proximity it resembled the Earth more than did the other celestial bodies. He believed it to be dark, shining by reflected sunlight.

On the whole, it must be admitted that, great thinker though Plato undoubtedly was, stupendous as was his intellect, he played a very unimportant part in the history of cosmological thought. At the same time, there is no doubt that Plato did a great deal to popularize the notion of the spherical form of the Earth. His books had a wide circulation in the ancient world, and his opinion carried extraordinary weight. By the time of Plato's death therefore, the fact of the spherical form was accepted on all hands.

(II) The Practical Period.

With Eudoxus of Cnidus, the cosmology of the Greeks entered on a new phase. With all his limitations, Eudoxus may be described as the first investigator of cosmological problems from a purely scientific standpoint. The changed outlook may be realized when we compare the methods of the previous thinkers with that of Eudoxus. The earlier philosophers had proceeded on the grounds of reason alone. Their method was deductive. Eudoxus on the other hand, was on the whole an inductive thinker. He was an observer of the phenomena of the heavens and to explain these phenomena, he advanced his famous theory of the homocentric spheres. Whether the theory was ever more to him than a convenient working hypothesis is uncertain. Dr. Dreyer, who has made a close study of the Eudoxian theory, believes that Eudoxus only regarded his spheres as "geometrical constructions suitable for computing the apparent paths of the planets."

The system was a very complicated one, but a brief sketch will suffice to explain its general nature. The Earth of course was believed to be spherical, occupying the center of the Universe and each celestial body was believed to be situated on the equator of a sphere revolving with uniform velocity around its poles. But Eudoxus, by observation of the heavens, was aware of the irregularities—retrogressions, variable velocities and stationary points—of the planets, and so it was necessary to postulate the existence of other spheres. The poles of each planetary sphere were believed to be attached to larger spheres, concentric with the others rotating round different poles with varying velocities. These poles of the second spheres were themselves rotating round other and still larger spheres. For the Sun and Moon Eudoxus found three spheres each sufficient, but in order to explain the complicated motions of the planets it was necessary to assume the existence of four spheres for each. For the fixed stars of course one sphere was sufficient. Finally Eudoxus had to assume the existence of twenty-seven spheres in all. On the whole, the theory, complicated and cumbersome though it was, accounted fairly well for the observed celestial motions. It explained the motions of all the planets, except Venus and Mars, but this is not to be wondered at, considering the insufficient observational data on which Eudoxus was compelled to work. Thirty years after the theory was first propounded, it was improved by Calippus, a pupil of Eudoxus, who is also known for his improvement on the Metonic cycle. Calippus considerably altered the system by adding a number of extra spheres to explain irregularities which had either escaped the notice of Eudoxus or which had been ignored.

The theory of homocentric spheres, as it is generally called, seems cumbersome, if not fantastic in the light of present-day knowledge, but viewed in its true light it marks an era in cosmological speculation. It was the first attempt to account for the observed phenomena of the Universe. Eudoxus was not a philosopher; he was first and foremost a mathematician and man of science and his theory was framed to explain observed facts. Indeed, as already mentioned, to him it may have been a convenient working hypothesis and nothing more.

If the theory was merely a theory to both Eudoxus and Calippus, it was a great deal more to Aristotle. In fact, it formed the basis of that great philosopher's cosmological conceptions, which exercised so profound an influence over human thought not only in his own day but throughout the post-classical period and the Middle Ages. When we realize the range of Aristotle's researches and his deservedly great reputation as philosopher and moralist, we are enabled to understand, partly at least, the reason of his long supremacy over the minds of men.

The natural philosophy of Aristotle was expounded in the eight books of his work on "Physics", in his four books on "The Heavens", and his four books on "Meteorologica." In the first of his books on "The Heavens" he argues that the material universe cannot be extended indefinitely in space, since a line drawn from the center of our Earth to a body indefinitely distant could not perform a motion of rotation in twenty-four hours. If the Aristotelian Universe was not infinite, however, it was regarded as eternal. In his cosmical speculations Aristotle was largely guided by his philosophical ideas. He adopted the view of Eudoxus as to the spherical shape of the Universe. On the ground that the sphere is among bodies the most perfect. In the spherical cosmos the most perfect sphere is that with the most perfect motion; and as the swiftest sphere is the most perfect in motion, the outermost is the most perfect of all. The entire argument is purely speculative and the outlook of Aristotle on the ultimate problem of the Universe contrasts strangely with the scientific procedure of Eudoxus, whose cosmological hypothesis he adopted. To Aristotle the spheres were actually in existence, portions of the vast mechanism of the Universe. He found it necessary—in order to explain why the motion of the outer spheres was not shared by the inner in spite of their connection—to add twenty-two extra spheres. Callipus had assumed the existence of thirty-three, so that as left by Aristotle, the system comprised fifty-five separate spheres.

Aristotle devoted considerable attention to the form of the Earth, its position in the Universe, and its possible motion. Aristotle bases his belief in the spherical shape of the Earth on both theoretical and empirical considerations. The former are of little account, but the latter are of more permanent value. He notes firstly the fact that the shadow thrown by the Earth on the Moon is always circular, showing that the Earth must be a sphere; and secondly, a journey north or south changes the apparent positions of the stars. He mentions the Pythagorean view that not the Earth but a central fire occupies the centre of the Universe; but this theory he rejects in favor of the view that the Earth is fixed and immovable in the centre of creation; and he does not seem to have been acquainted with the view of a rotation of the Earth on its axis.

Aristotle is careful to distinguish between the heavens, the region of unchangeable order where circular motion prevails, and the region below the lunar sphere in which are placed the four elements, earth, water, air and fire. The ether he believes to become increasingly pure at greater distances from the Earth's surface; and in the upper atmosphere comets and meteors and aurorae were believed to be produced. He also believed the Milky Way to be an atmospheric phenomenon.

After all the cosmological ideas of Aristotle do not seem to be very far in advance of those of earlier thinkers; and indeed in some instances his opinions were decidedly reactionary. There is therefore a natural temptation to ask why the opinions of Aristotle on cosmology should have so great weight in later years. The answer is to be found in the unique position occupied by Aristotle in the history of thought. He was not merely an astronomical or scientific thinker, or a great mathematician. He was the most commanding figure of his age and in him, so to speak, was summed up the scientific and philosophic culture of the Hellenic world. Thus the pronouncements of Aristotle, even in the Hellenistic period, were invested with peculiar authority.

We find, for instance, that among men of philosophic or scientific mind, the spherical form of the Earth was never again seriously disputed; while the erroneous doctrine of the fixity of the world in the centre of the Creation was invested with all the authority of the greatest of philosophers.

Yet, almost contemporary with Aristotle, there were two distinguished Greeks who seem to have grasped the truth in regard to the Earth's place in Nature. Heracleides of Pontus was a pupil of Aristotle, but appears to have had the courage to think for himself on the system of the world. In the words of the commentator Simplicius "Heracleides of Pontus, assuming the Earth to be in the middle and to move in a circle, but the heavens to be at rest, considered the phenomena to be accounted for." Actius, another ancient writer, remarks that Heracleides considered the Earth to move "not progressively, but in a turning manner, like a wheel fitted with an axis, from west to east, round its own centre." In other words, Heracleides believed that the Earth turned on its axis in twenty-four hours and thus explained the apparent motion of the sphere of the fixed stars. Another forward step was taken by Aristarchus of Samos, who boldly declared that instead of the Sun moving round the Earth, our world travelled round the Sun. "He supposes", said his contemporary Archimedes, "that the fixed stars and the Sun are immovable but that the Earth is carried round the Sun in a circle." His brilliant intuition, however, was destined to obscurity. It did not harmonize with the opinions of Aristotle and the authority of the great philosopher was supreme. Besides, even in those Pagan days, the heliocentric theory was considered a dangerous doctrine. According to Plutarch, "Cleanthes held that Aristarchus of Samos ought to be accused of impiety for moving the hearth of the world, as the man, in order to save the phenomena, supposed that the heavens stand still and the Earth moves in an oblique circle at the same time as it turns round its axis." Aristarchus was the last thinker of the Greek world who strove to find the physically true system of the Universe. The theories which followed were merely mathematical hypotheses representing the motions—regular and irregular—of the various planets.

It is somewhat remarkable that while more and more stress was laid on Aristotle's opinion as to the immobility of the Earth, the astronomical theory on which he based his hypothesis—the spheres of Eudoxus—was soon discarded. The rise of practical astronomy, by demonstrating its inadequacy hastened its rejection. The necessity of regulating time, the need for an accurate calendar, had stimulated observation of the Sun and Moon and this in turn influenced other branches of astronomy. At Alexandria, under the patronage of the dynasty of the Ptolemies a school of astronomy was founded and systematic observation of the heavenly bodies was made. As Dr. Dreyer has well remarked, "Vague doctrines and generalizations were abandoned, while mathematical reasoning founded on observation took their place. That this change occurred about the middle of the third century was a circumstance not unconnected with the simultaneous rise of the School of Stoic philosophy. Both in abstract philosophy and in science the wish to get on more solid ground now became universal and no science benefited more by this realistic tendency than astronomy."

To Apollonius of Perge is due the distinction of inventing the famous theory of epicycles which superceded the spheres of Eudoxus. After using for some time the so-called theory of "excentric circles," Apollonius put forward the theory of epicyclic motion. The idea of concentric spheres was abandoned; Sun, Moon and stars were assumed to be in motion round the Earth in circular orbits; but some explanation had to be given of the irregularities of the celestial motions. In essence, the systems of Apollonius, Hipparchus and Ptolemy were identical, but the latter scientist worked the epicyclic theory to its fullest perfection.

The epicyclic theory is not easy of explanation and we cannot do better than reproduce the exposition given by Sir Robert Ball in his sketch of Ptolemy. He takes the typical case of Mars with its irregular motion. "We have the Earth at the centre and the Sun describing its circular orbit around that centre. The path of Mars is taken as exterior to that of the Sun. We are to suppose that at a point M there is a fictitious planet which revolves around the Earth uniformly in a circle called the deferent. This point (M) which is thus animated by a perfect movement is the centre of a circle which is carried onwards with M and around the circumference of which Mars revolves uniformly. It is easy to show that the combined effect of these two perfect movements is to produce exactly that displacement of Mars which observation discloses."

This is a sketch of the theory at its simplest, but it is sufficient to illustrate its general principle. As astronomical observation progressed, new irregularities were discovered and had to be accounted for. Hipparchus of Rhodes will ever hold the chief place among the astronomers of antiquity. Not only did he form a catalogue of stars, and thus lay the foundations of practical astronomy, not only did he discover the precession of the equinoxes, but he succeeded in working out solar and lunar theories. He did not satisfactorily explain the motions of the planets on the epicyclic theory, and in fact he merely accepted the epicyclic theory, as a convenient working hypothesis.

In Ptolemy of Alexandria, who lived three hundred years after Hipparchus, ancient science reached its culmination. In his great work the *Syntaxis* commonly known as the *Almagest*, he develops the theory to its fullest extent. In the first book of his great work, he demonstrates that the Earth is a sphere fixed and immovable in the centre of creation, and the heavens is also a sphere, rotating in twenty-four hours round an axis. This is the fundamental assumption of the Aristotelian philosophy and Ptolemy accepted it. He worked out carefully the epicyclic theory in the light of the discovery of new irregularities in the celestial motions, and as a result a number of extra circles and epicycles had to be introduced.

Like Eudoxus and Calippus, Apollonius and Hipparchus, Ptolemy does not seem to have troubled as to the actual physical truth of his system. "I do not," he said, "profess to be able thus to account for all the motions at the same time; but I shall show that each by itself is well explained by its proper hypothesis." If to Ptolemy the theory was merely a working hypothesis, it was soon regarded by the intellectual world at large as the true system of the world. The philosophy of Aristotle and the science of Hipparchus and Ptolemy was the last word of ancient cosmological thought; and during the Middle Ages the word of these masters was final.

In the Hellenistic period—after Aristotle and Plato—men do not seem to have troubled over purely cosmogonic problems. There was little speculation as to how the world came to be. The Stoic School in so far as it concerned itself over such matters followed Aristotle. The pantheistic nature of the Stoic philosophy led these thinkers to the doctrine of an all-pervading primary substance co-extensive with matter. This primary substance identified by Cleanthes with fire, was generally regarded as one with the Deity. Thus the Stoic cosmogony resulted in pantheism.

The atomist school, represented among post-Socratic thinkers by the Epicureans, found its leading exponent in the Roman poet Lucretius. On the whole, Lucretius is not original; he merely reproduces the ruling ideas of Leucippus and Democritus. He pictures the concourse of atoms in indescribable confusion at the beginning of time. "At last the parts began to fly asunder, and like to join to like and mark off the members of the world and every one of its mighty parts—to separate high heaven from earth and let the sea spread itself out apart, and also let the fires of the ether spread apart, pure and unmixed." We cannot but be impressed with the retrogression illustrated by the cosmological fancies of Lucretius; and thus, he counts for little in the history of cosmology.

Hellenic culture had exhausted itself at the beginning of the Christian era; and although it lingered on for some centuries, it counted for little in the world's thought. When the Emperor Justinian suppressed the Neoplatonist Schools in 529 he merely gave legal expression to an accomplished fact. The long night of the Middle Ages had begun.

THE THEODOLITE FOR TESTING TELESCOPIC SPECULA.

A new use for a familiar instrument.

RUSSELL W. PORTER.

It is a well known fact among amateurs who are attempting their own reflecting telescopes, that when the stage in making the concave mirror is reached where the surface changes from a sphere to a paraboloid, a somewhat precise tool must be provided whereby the different foci found in the neighborhood of the center of curvature, may be located and measured: and that these positions, all lying along the axis of the mirror, and within a few tenths of an inch of each other, must be determined within an error of the order of 1/100 inch.

Home made affairs will not, as a rule, stand up under this degree of accuracy, and, in casting about for the right device, the writer found that the theodolite, or ordinary surveyor's transit might be so used as to provide an almost ideal instrument in the laboratory tests of specula.

The transit is set up on a firm stand with its vertical axis at about the distance from the glass equal to its radius of curvature, with two of its leveling screws parallel, and the telescope tube at right angles, to the axis of the mirror. A piece of tin foil is glued over the opening in the diagonal eyepiece of the telescope, and a pinhole formed by puncturing with a needle. A lamp at a convenient distance throws light down the telescope tube to the pinhole, and the arrangement is ready for use.

It so happens that the outer edge of the prismatic eyepiece provides the knife edge, and posesses the great advantage of being very close to the pin hole. The action of the instrument is then as follows.

Having so adjusted the speculum on its stand, that it returns the light to a point just outside the knife edge, the observer returns to the transit and, by means of the leveling screw farthest away from the pin hole, brings the knife edge up to and in interference with the reflected cone of light. If the reflected image is not in the same horizontal line with the pin hole, it may be made so by depressing that end of the telescope with the telescope tangent screw.

The horizontal tangent screw may now be used to bring the knife edge to any desired focus, and the difference of the readings of the horizontal circle, in arc, will give the relative positions of the various foci.

To obtain the absolute measures of these distances, find the horizontal distance of the knife edge from the vertical axis of the instrument, and call it R. Let a and a' be the horizontal circle readings of any two foci. Then

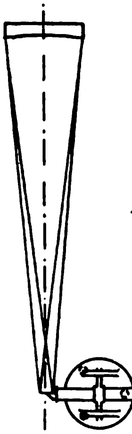
$$a' - a$$

will be the angle through which the knife edge has swung in passing from one focus to the other, and

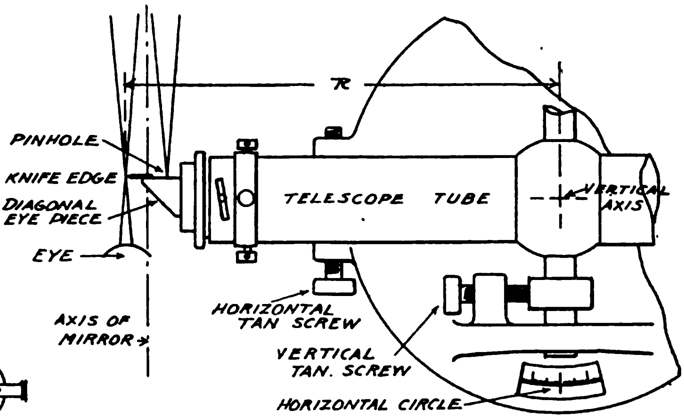
$$R \sin (a' - a)$$

will be the distance between them, nearly.

The accompanying diagram will make clear the above description.



MIRROR AND THEODOLITE.



ENLARGED VIEW SHOWING PARTS OF THEODOLITE USED IN TESTING MIRRORS

One or two other points may be noticed. If the tests are to be conducted with an immovable light source, the artificial star may come from a separate stand, and the foci found and measured as above, with the theodolite. By attaching an eyepiece to the telescope close to the knife edge, the image of the pinhole may be examined both in and out of focus, by use of the horizontal tangent screw. This virtually makes a telescopic focusing rack out of the transit, but an extremely sensitive one with a scale (the horizontal circle) attached.

This adaptatation of the alt-azimuth instrument only emphasizes its former reputation of being a universal instrument, and, where available, such as in institutions likely to possess valuable mirrors, furnishes a ready and accurate means of verifying their optical properties.

Land's End, Port Clyde, Maine.
January, 1916.

THE PARTIAL SOLAR ECLIPSE OF FEBRUARY 3, 1916.

G. L. HARRELL.

The partial eclipse of the sun on February 3, 1916 was observed at the James Observatory under the most favorable conditions. On January 31, it rained and the ground was covered with sleet and snow on February 1, but February 2 dawned calm and clear and the same was the condition on the morning of February 3. The sky was perfectly clear as it always is after a good rain, there was no wind and the temperature the night before was recorded at 19 degrees above zero, the lowest for the winter.

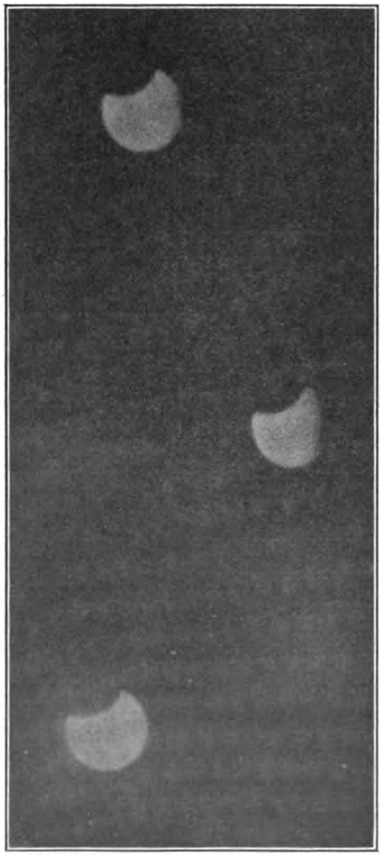


FIGURE 1.
Partial Eclipse of Sun, Feb. 3, 1916.

The time for first contact had been computed for our position as $8^h\ 35^m$ a. m. Central Standard Time. Promptly on the minute the moon began to encroach upon the face of the sun and continued its journey thereon until $10^h\ 43^m.18$ at which instant the last contact was observed. About 27 per cent of the sun's diameter was obscured. Just before the last contact the writer removed his eye from the telescope long enough to look through a smoked glass to determine how long the naked eye might see the sun in eclipse. It was seen with the smoked glass fifty-six seconds before the last contact was observed with the telescope. No later effort was made to see it with the naked eye for fear of losing the final contact with the lens.

The class in astronomy met at the observatory at an earlier hour on that morning that they might see the eclipse. Of course there was nothing out of the ordinary to be observed, and the only interest, to them, was the novelty of seeing an eclipse through the telescope.

The photograph was made with a 3½″ portrait lens (E. Suter Aplanat B No. 7) and is enlarged two times. Three exposures were made upon the same plate which was a Stanley Sensitometer 50.

The developing, printing, and enlarging were done by the Daniel Studio, the leading photographer of our city. It was through the courtesy of the same establishment that we had the use of the portrait lens. The shaded phase on the limb of the sun was produced by the edge of the opening in the dome. The camera was preceding the tube and was thrown into the shadow before it was noticed otherwise.

No preparation had been made to make the photograph of the eclipse as the camera was used for work at night on other objects. There was an unused plate and the writer exposed it to see how well the small lens would do in such work.

The writer will not end what he has to say in regard to this eclipse without making a few statements in regard to the total eclipse of 1918 June 8. Some time ago he made some computation as to the path of totality with respect to the position of his own observatory and came to the conclusion that the path would pass over Jackson or just to the north and he is glad to see his estimate confirmed by the Ephemeris for 1918. It will be found by examining the Ephemeris for 1918 that of those observatories in the United States, seventy two in all, having their positions indicated, Denver is the only one in the path of totality. The Ephemeris also shows Jackson in the path, which of course includes the James Observatory though, due to a failure to get the correct information to them in time, its position is not shown in the Ephemeris.

As our observatory is one of the two favored by the eclipse of 1918 June 8, I will give the coördinates and constants that are being used at the present time.

The order given in the Ephemeris will be followed here.

Place—Jackson, Miss.
Latitude $+32^\circ\ 19'\ 29''$.
Reduction to Geocentric Latitude $-10'\ 23''.548$.
Altitude meters: 109.
Log ρ: 9.9995865.
Longitude from Greenwich: $+6^h\ 0^m\ 43^s$.
Reduction from Greenwich to Local S.T.M.N. $+59^s.25$.
Latitude—Authority (Observations by Director).
Longitude " (Taken from Topographical Map U.S.G.S. Jackson Quadrangle Ed. Aug. 1908).

James Observatory.
Jackson, Miss.
February 28, 1916.

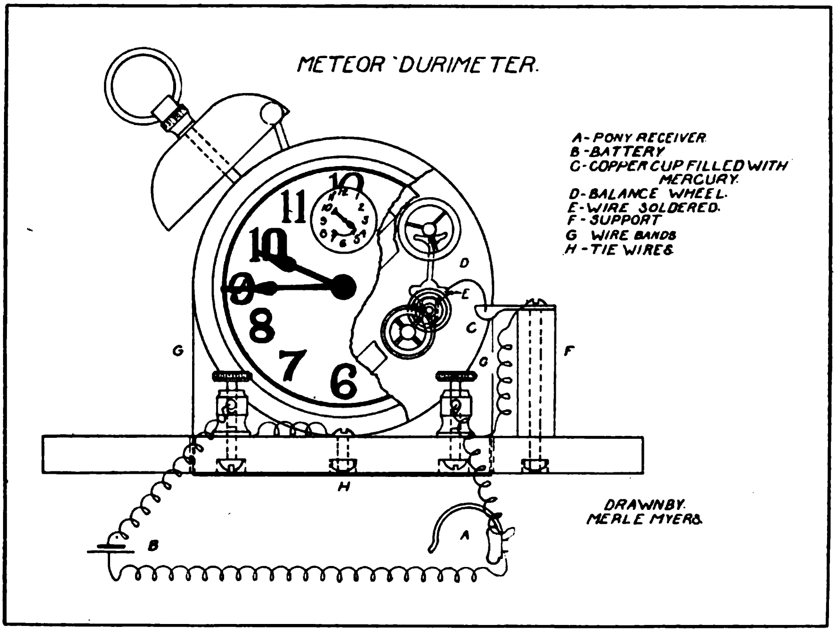
A DURIMETER FOR METEOR OBSERVATIONS.

LINCOLN LAPAZ.

Perhaps no more difficult a task can be required of an inexperienced observer than that of estimating the duration of an extremely transient appearance. Nowhere is the attempt to make such an estimation more perplexing than in meteoric work, especially since the mind is occupied in classifying the observed shooting stars as to color and magnitude or in determining the position of the apparent paths. Continued practice will, of course, relieve the arduousness of forming such estimations; nevertheless the amateur who desires to set down only such data as he sincerely believes to be correct will spend many puzzled moments over his recorded durations if he has nothing to guide him in his judgments. However, by introducing an alarm clock having a slightly modified escapement in an electric circuit containing a telephone receiver, it is possible to obtain a contrivance which will assist greatly in ascertaining the duration of visibility of meteors.

The clock is the only thing which must be changed, and it requires only slight alteration. After the back or face of the clock has first been removed, that part of the escapement which we are to work with may be recognized by its backward and forward motion and, in some cases, by its anchor like shape. It is designated by E in the accompanying drawing. The escapement is next brought to the side of the clock by tilting the timepiece as illustrated in the diagram and the wall of the clock cut away in front of it. A piece of No. 18 aluminium or copper wire, one inch in length, is pushed thru the aperture thus formed and soldered to the lower extremity of the anchor escapement in such a manner that a vertical motion will be given to the wire when the clockwork is in motion. When the clock is secured to the base by wire bands and screws, a tiny metal dipper, conveniently formed by denting one end of a two inch tin or copper strip, is mounted on a spool or similar support and fastened just below the outer end of the wire on the escapement, care being taken that the dipper does not actually touch any part of the clock. The end of the wire is now bent so that on its downward motion it will dip into the metal bowl. A copper wire is run from any portion of the clock to one of two binding posts fastened on the clock's base, and a second wire from the metal bowl to the other post. Finally mercury is poured into the dipper until the end of the wire, when at the lowest point of its path, just touches the surface of the liquid.

In use the clock is connected in a circuit with a dry battery and a telephone receiver as shown in the figure. The receiver should be of the pony or wireless type and must be provided with a headband; it is imperative that both hands be unencumbered. It is usually most convenient to leave the clock and battery indoors and run leads from the binding posts on the clock base to the place of observation where the receiver may be connected up.



If the receiver is put to the ear when the arrangement is wired up, a short buzz will be heard whenever the wire dips into the mercury and closes the circuit and another buzz when the wire leaves the surface of the mercury and breaks the circuit. Moreover the sound produced at magnetization has a quite different tone quality from the sound brought forth by demagnetization; and since the circuit is opened and closed four times a second, the interval between two dissimilar buzzes represents a quarter of a second and that between two consecutive like sounds a half of a second.

When the durimeter, as the appliance may be called, is first used, it will be found helpful to beat time with the fingers, in the unoccupied moments between meteors, until the rythm of the sounds produced in the receiver is thoroughly familiar. Moreover no opportunity for practicing the estimation of short durations should be lost, for the conflicting reports received from the various witnesses of every great meteor testify to the need of observers prepared to gather trustworthy data from such rare phenomena.

It is true, of course, that the estimations still depend on the individual judgment, but with the constant standard of comparison and the rapid familiarity with brief durations which the apparatus affords it appears that more accurate estimates are certain.

High School, Wichita.

NOTE:—Mr. Lincoln LaPaz, of Wichita, Kansas, observed during 1915 over 1500 meteors, which he reported to the American Meteor Society. The last 600 of these were observed, using the instrument, described in the above article, to estimate their durations.

The details of these observations, which will appear in full in the 1914-1915 report, now about to be printed, were of such interest, that Mr. LaPaz, at my request, prepared a short account of his instrument for POAULAR ASTRONOMY.

Judging by the consistency of his results and their evident accuracy, all members are urged to have a similar one made for their use in future. The estimate of a meteor's duration is certainly the most uncertain of all the data our observers try to obtain, and the use of this simple device should make their estimates several times more accurate.

CHARLES P. OLIVIER.

Leander McCormick Observatory,
University of Virginia.

REPORT ON MARS, No. 16.

WILLIAM H. PICKERING.

After a brief reference to a suggestion of Professor Russell, which will serve excellently as an Introduction, this Report will be devoted to a *resumé* of a few of the more important conclusions that we have reached as the result of a preliminary study of our observations during the past opposition.

PROFESSOR RUSSELL'S SUGGESTION.

In the Scientific American, March 4, p. 248, Professor Russell devotes a considerable portion of his space to a discussion of the appearance of the canals of Mars as described by various observers. As one of the four specialists, to whose work he particularly refers, the writer may say that he considers the article an eminently fair one, and that the explanation given for the fact that Dr. Lowell draws the canals very narrow, while some of the other observers draw the majority of them fairly wide is probably the true one. This explanation in brief is that it is merely a question of the personality of the observer.

Professor Russell then goes on to suggest that a series of disks should be prepared by a committee, and these disks observed by the four specialists through their telescopes, none of the observers having previously seen the disks near at hand. By means of a comparison of these drawings Professor Russell thinks it might be possible to determine the real nature of the markings on Mars. The writer, having used in the course of his observations various artificial disks, from the 8-foot round canvas screen erected in 1892 at an altitude of something over 16,000 feet in the Andes, and which was observed from a distance of eleven miles,* to the 2-inch glass plate placed in front of an oil lamp and condensing lens, and viewed from a distance of 1100 feet in Jamaica,† would like to make a few remarks on this suggestion.

Suppose that one of the disks prepared by the committee contained simply two lines, one very narrow and black, the other wider and fainter. It is quite possible that Dr. Lowell would represent these markings by two narrow dark lines exactly alike. It is possible that Professor Barnard, who is placed by Professor Russell at the other extreme of the observers, would represent them by two faint broad bands, while M. Jarry Desloges and the writer who in Professor Russell's opinion occupy an intermediate position, might, if the markings were faint enough, represent them both as lines, and if they were darker represent them both as bands.

Now what would the committee learn by a comparison of these results? In the first place they would learn that all four of the observers had represented the markings incorrectly. In the next place they would learn the peculiarity of each observer's method of representation, which would in this case be what we have here assumed. But would the committee learn anything about the canals on Mars? They would in part have explained the discrepancies in the observer's work, but I believe that is all. The same would be true of any other markings that the committee might have prepared.

Among the four or five larger and more conspicuous canals one can often see that there is a real difference in width, but we can also occasionally see that there is a real difference in blackness. Now what can we say about the fainter canals that are so difficult that they can only just be distinguished? Differences in width seem to be more frequent than differences in blackness, and are therefore generally assumed by the writer to be the real cause of the difference in appearance of the canals, but it is quite likely that in some cases both causes affect them. To come back to the final, and also the initial question, however, are the markings in reality canals at all, that is continuous narrow dark bands or lines, or is the appearance due simply to comparatively broad irregular areas of unequal density and size? Some evidence bearing on this question has been collected during the past opposition.

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* Annals of the Harvard College Observatory **32**, 117.

† Report on Mars, No. 11.

Appearance and Nature of the Canals.

About March 1 the character of some of the canals observed changed very markedly. Prior to that date most of them had existed as broad smoothly curved lines. While many of these remained visible, there now suddenly appeared a number of new canals, very narrow, and some of them strikingly straight and artificial looking. Their advent had been foreseen, and indeed referred to in our first report, as well as in several others. Thus in No. 8 we say "at the next opposition he [the writer] expects to draw them appreciably more narrow than in his present series of sketches." Although anticipated therefore, from earlier studies in Peru and elsewhere, it must be admitted that the suddeness of their appearance was a little startling. On February 28, ω 30°, M. D. May 18, seeing 10, no canals were detected on the disk save Deuteronilus, which appeared as a broad faint band some 300 miles in width. Two nights later March 1, ω 35°, M.D. May 19, seeing 8 and 7, the band had narrowed to about 0.3 its former width, and five other canals had appeared, all of them comparatively narrow and sharply defined. While the seeing was inferior to that on the night of the earlier observation, the canals were both sharper and distinctly narrower. What was particularly striking in some instances was their straightness. It gave them an artificial appearance that should be seen to be fully appreciated.

March 8, ω 332, the canal known in different sections as Protonilus and Deuteronilus stretched in a nearly due east and west direction, as an apparently absolutely straight line, from Coloe Palus to Siloe Fons, where it was joined nearly at right angles by the equally straight Gehon, slightly wider, and about three-fifths as long. Doubtless both canals were arcs of large radius, but they appeared absolutely straight to the eye. The width of Protonilus was measured as we shall see later, and found to be 94 miles. Its length was 1860 miles, or practically just 20 times its width. If the reader will draw on paper a rectangle five inches long by one-quarter of an inch in width, he will get somewhat the effect that this canal produces. Save the lake, Ismenius, located at its middle point, it did not seem possible that it contained any irregularities or sinuosities equal to its own breadth, nor perhaps even half as great.

On March 15 Mars was in conjunction with the Moon, the two bodies being at the same altitude, and some 5° apart. The Moon was 3.5 days short of being full, and the coarser lunar canals visible with a field or opera glass, and represented in Report No. 6, Figure 1, were conspicuous. Mars was examined with a power of 660, which brought it up within a distance of about 100,000 miles. The Moon was examined with a power of 4, which brought it within a distance of 60,000 miles. Objects of the same size upon their surfaces would therefore have about the same angular dimensions. It is recorded after alternately examining first one and then the other, that the two northern canals of Imbrium were just about as distinct as Thoth and Nilosyrtis. These are at present the two most conspicuous canals on Mars. They were seen on a much darker background, but had about the same apparent breadth as the two lunar canals. The Copernicus canals were not so strongly marked at this phase, and the components of the narrow double in the south-western quadrant were much narrower.

On March 21 it is recorded that Cerberus, another very distinct canal, was just about as clear and wide as those near Copernicus with the field glass. The Moon was then two days past the full. The writer takes this opportunity to state, that since Report No. 6 was written he has found that certain of the lunar canals there mentioned had been previously described and pictured by Dr. Cerulli, Flammarion II, 317. Dr. Cerulli's drawing is a little difficult to understand at first, as he does not show conspicuously the generally recognized features of the Moon, but by means of the description in the text, it is evident that several of his canals are identical with those shown in our report.

If instead of viewing the Moon with a field or opera glass, we use a small telescope magnifying only ten or twelve times, these lunar canals entirely disappear. Even with magnification eight they are hardly visible. In their place we find a more or less continuous line of broad shaded areas of irregular shape, and of varying and irregular density. If we could use double the magnification on Mars, let us say 1300, would the same result be obtained? The writer uses habitually a magnification of 660, half as high again as anybody else, but to increase the magnification further would be worse than useless, less instead of more would be seen.

But suppose the canals of Mars are of irregular outline and density, and not smooth and straight, what of it? So too our cultivated fields would appear to an observer on the Moon. The lunar canals act in a very different manner from the Martian ones, and are not subject to such singular, irregular, and unaccountable changes of appearance and position. The writer wishes distinctly to state that it is not so much the *straightness* of the canals of Mars, as the public generally imagines, and as Professor Russell in his article suggests, as it is their *arbitrary and unaccountable changes*, that make us believe them artificial. Even if the canals were really perfectly straight and uniform, it would certainly be impossible for us to prove it.

FUTURE POSSIBLE MAGNIFICATION.

It may now perhaps be asked is there any hope then that we may ever use a power of 1300 on Mars. Probably not at any observatory with the telescopes now existing, because these telescopes have all been carefully tried, and 660 is the highest power that has proved practicable anywhere. It has however been shown here that it is perfectly possible to use to advantage a magnification of 60 per inch of aperture on Mars, whenever the seeing reaches 8, even for an 11-inch lens. It is not believed that the seeing in Jamaica is any better than in many other portions of the tropics, where uniform temperature and atmospheric pressure prevail. It seems perfectly possible theoretically to use a power of 60 per inch of aperture even for lenses 20 or 25 inches in diameter, provided the seeing reaches as high as 10. In summer seeing 10 is often reached in the tropics, and 12 is not uncommon. But in the August opposition Mars is at only two-thirds the distance that it was this year, so that with twice the aperture, used at that season of the year, it might even now be perfectly practicable to obtain the desired enlargement of its surface details. In order to compute the necessary aperture of our telescope we will start with the fact that the lunar canals are all resolved into irregular areas when the magnification is such as to bring the Moon within 30,000 miles of us. To bring Mars within this distance at an August opposition would require a magnification of 1,200. Using a magnification of 60 per inch of aperture would require a 20 inch glass. To be on the safe side we will say a 24-inch telescope.

August oppositions occur once every thirty-two years, and the next one will come in 1924. Twenty-four inch telescopes are not now uncommon, and as the advantages of the tropical atmosphere for astronomical research gradually become more and more widely known, it does not seem improbable that some day someone will locate a telescope of this size somewhere in the tropics, and we may then add materially to our present knowledge in all those directions where the best of seeing is a matter of vital consequence.

WIDTH AND VISIBILITY OF THE CANALS.

On March 14 and 15 the widths of several of the canals were measured by means of the Canal Scale, Report No. 7. A magnification of 660 was used in all cases, two measures of each canal being made when possible. The corrected mean diameter of the planet expressed in arc was 11″.67, and the equivalent of 1″ was 361 miles, or 580 kilometers. The widest canals measured, Nilosyrtis and Thoth were found to have a breadth of 0″.30, and the narrowest Astusapes 0″.08. The mean average deviation was 0″.025, 9 miles, or 14.4 kilometers. The following widths were deduced, Protonilus 94 miles, Astusapes 30±6, Nilosyrtis 106±12, Thoth 106±12, Hyblaeus 42±6, Cerberus (mean) 94, Hades 94. An early measure of Cerberus was rejected as obviously erroneous. Its breadth varied appreciably in different places, being widest near Charontis. Astapus and Nasamon were both visible and rather difficult. They were the same width as Astusapes, 30 miles. The seeing varied from 9 to 11, so that this width may be considered about the narrowest visible when the planet is at the mean distance computed for these dates, 74,000,000 miles. When nearest us the minimum breadth would be reduced to about 15 miles.

The density of Nilosyrtis and Thoth was equal to the darkest band or stripe one could make on white paper with a number 4 pencil. It is thought that a month or two earlier in the season they were somewhat darker, but not so dark as the marking of a number 3 pencil. These measures may be compared with some made last November, see Report No. 13, and also with some made upon an artificial disk, Report No. 11, from which it was concluded that with moderately good seeing we should be able to detect a canal whose width was only 9 miles, if it were absolutely black.

Comparing these results again with observations made on the same night upon the two canals visible on the outer slopes of the lunar crater Aristillus, colongitude 39°.8, we find that with our 3-inch finder and magnification 240, the Aristillus canals are a trifle easier than Astusapes in the 11-inch. The breadth as measured with the finder was 0″.18 or 1100 feet. As measured with the 11-inch 0″.13, 800 feet, or 240 meters. This may indicate that with a still more powerful telescope than the 11-inch, the equivalent breadth of Astusapes might be also reduced, so as not to much exceed 20 miles. The density of the Aristillus canals was the same as those of Mars, that of a No. 4 pencil. Both Nilosyrtis and Thoth could be detected, although rather faintly in the finder. They were easier early in the season, and were not difficult at that time. With the 11-inch, Nilosyrtis and Thoth were both much easier than the Aristillus outer canals, while Astusapes was clearly more difficult.

ARYN, ELYSIUM, THE SNOW CAP, AND VEGETATION.

While for many years changes on Mars have been recorded by all careful observers, it was not until the last two years that they have been recognized as such a constant feature of the planet, and expected to occur anywhere at any time. Accordingly a universally accepted feature such as Aryn was formerly believed to be constantly present. The feeling was, that if it was not seen, it ought to have been, and so it was put down in the drawing whenever that part of the planet was visible, whether it was really seen or not. This, it is believed, accounts for its appearance on so many of the drawings made during the opposition of 1913-14, when it is now practically certain that it was not really visible at all.

In point of fact Aryn did not appear this year before March. On the first it was strongly suspected, but not surely seen. ω 3°.9, ⊙ 61°.5 M. D. May 19, seeing 8, 7. March 3 it was recorded as pretty certainly there, but even on March 5, ω 0°.5, although certain, it was only very faintly marked, seeing 9. The appearance was little more than an indication of Aryn, for it consisted in a very shallow notch in the northern border of the bay of Sabaeus, with a scarcely noticeable lightening extending about one-third way towards the southern border. Indeed it would scarcely have been seen had not a special search been made for it. In 1914 it was not until April 14, three months after opposition, that Mars reached the same solar longitude ⊙, that it had this year March 1.

The same remark is true of the pentagonal form of Elysium. Doubtless at certain seasons Elysium is pentagonal. Observers believed it was always so, and drew it accordingly, as a matter of habit. One cause of these errors is that observers have heretofore used too low powers,—possibly all that their aperture or their atmosphere would permit, but still too low. Mars is a very small object at the best, and the details of its surface minute. To see them well, and make no gross errors, we must have a reasonably large aperture, and we must have good seeing, and high magnification. Under these conditions, and a magnification of 600 or 700, the planet may be less distinct than with a power of 400, and certainly less pretty as a show object, but the observer familiar with its surface will see all its generally accepted details, such as the two above mentioned, more certainly, and can draw them more accurately, than when they are so small as to be on the very limit of distinct vision. If he is interested in hunting for fine canals, he may later use the low power, and insert what he sees on his previous sketch, but that is the only way that it should be used.

There is another interesting feature about Elysium as it has been seen at the past opposition. Its outline this year has been nearly circular, and the inner edges of the bounding canals, Cerberus, Styx, and Eunostos were all sharply defined, while their outer edges were less so. This is precisely the reverse of what is shown in Schiaparelli's drawing in May 1888, when the outside is sharp, and the interior hazy. Flammarion I, 423. We have already seen in Report No. 13 that the advancing or eastern side of the north and south band was sharp while the other side was hazy. We have also seen by Report No. 12 that there was evidence that Elysium was subject to changes in size. It therefore appears possible that Elysium has been changing its size and growing smaller, while in 1888 it was growing larger. This suggestion is corroborated by measures of the drawings made hitherto this year, although the change found is so small that it can not be called conclusive. The mean inner meridianal diameter in January measured 859 miles, in February 806, and in March 778. Both inner and outer edges are now fairly sharp, so that it seems likely that the minimum size has been attained. It is now clearly smaller as well as rounder than it was early in the previous opposition of 1913-14.

The snow cap is now appreciably smaller than it was at the last opposition, at the same season of the year. Since as we have already seen it was much larger earlier in the season than at the former opposition, we can hardly doubt but that they have been having rather warmer weather on Mars this year. It will be of interest to note if this means a warmer summer than usual for our Earth.

It may be mentioned here that although we have watched the planet under very satisfactory circumstances throughout the whole of the spring of its northern hemisphere, yet not a trace of green has been detected in that region. The impression gathered has been that all the dark northern areas, and most of the canals observed have been simply marshes, or moistened soil. Possibly greens will appear in their autumn, or before. On the other hand the greens of the southern hemisphere, during their autumn, have been at times very striking. They have now all disappeared.

SHIFTING FEATURES, AND PERIOD OF ROTATION.

In our last Report we referred to the large bay similar to Titanum which had recently appeared at the junction of Cimmerium and Laestrigon, and was shown on our drawings of February 7, 9, and 12. This bay is also shown in four drawings made by two of our Hawaiian correspondents, Mr. Midkiff and Dr. Romberg, on the evening of February 17. It appears again of large size on two drawings made February 10 and 14 which have recently been received from Mr. L. J. Wilson. On the latter drawing it is just about equal to Titanum, which is also shown not far from the limb. This drawing furthermore agrees in showing Titanum unusually far to the east of Charontis, that is in a very low longitude. In our last Report we gave it as the result of the mean of the transits taken in December, January, and February as located in longitude 156°.4±0°.8. It was impossible to obtain its position accurately this past month, but on March 29 it was found to be but little over 159°, which indicates that it is now gradually shifting back to the position given to it on the map, in longitude 170°. The shift recorded is equivalent to 13°.6, a distance of 500 miles, or 800 kilometers.

The following determinations of the longitude of Margaritifer at the mouth of the Indus, have been secured by different observers:—

Schiaparelli	1877-79	17°.3	Lowell	1903	20°.7
Wislicenus	1890	23.9	Lau	1909	24.5
Pickering	1892	17.2	Jarry Desloges	1912	15.5
Lowell	1894	16.6	Pickering	1916	15.1

This last determination was made March 5, and rests on a single transit only, but serves to confirm the value of M. Jarry Desloges, whose observation indicates that the shift since 1909 has been about 350 miles, corresponding to an interval of 40 minutes in the time of transit. Since this point is near the equator it is readily seen, and its position can be determined with considerable accuracy. Observers do not usually give average deviations, but with careful work they should lie between 0°.5 and 2°.0, the corresponding errors being 2^m and 8^m in the time of transit.

The longitude of the northern tip of the Syrtis Major was determined on the nights of March 9, 11, and 14, results 283°.4, 282.3, 286°.9, mean 284°.2 ± 1°.8. Professor Barnard at my request made a determination March 15, obtaining 285°. This compares with Dr. Lowell's result obtained in 1903 of 284°.77 ± 0°.36, and that of M. Jarry Desloges in 1912 of 284°.0. These results agree very satisfactorily, and little more could be desired. If we go back twenty years however, after making the correction of —4°.8 made by Marth in the Ephemeris for 1896, we find that the longitude of the Syrtis according to Wislicenus in 1890 was then 291°.0. By the writer's results at Arequipa in 1892 it was 291°.3, according to Lowell in 1894 it was 287°.6 and finally according to Lau as late as 1909 it was 289°.4. The mean of the first four results is 284°.5 ± 0°.4, the mean of the last four 289°.8 ± 1°.3, difference 5°.3, 183 miles or 293 kilometers. Whether we include Lau's recent determination among the early ones or not makes little difference in the final result. Schiaparelli's determination in 1877, 285°.5 agrees well with the latest figures.

The Syrtis Major is the most conspicuous marking upon the planet. There is probably no point on the whole surface whose longitude is more readily determined than its northern tip. A difference of 5°.3 corresponds to a difference of 22 minutes in the time of transit of the central meridian. It is inconceivable that either set of observers should have made such a mistake. That the difference is not due to an erroneous rate of rotation is shown by the fact that after an interval of 39 years, Schiaparelli's determination in 1877 of 285°.5 is but 1°.0 above the present mean value. Indeed the only possible explanation of these discrepancies seems to be that the point has shifted across the planet's surface.

A very valuable piece of evidence on this question may be obtained from Dr. Lowell's careful measures of Aryn in 1894 and 1916. In the Annals of the Lowell Observatory I, 53 he states that as the result of his observations in 1894 it appeared that Fastigium Aryn passed the central meridian by "the unmistakable amount of twenty minutes behind time." In consequence, on the next page, he offers the suggestion "that the received time of rotation of the planet is a trifle too small." Twenty minutes of time corresponds to a correction of 4°.8 of longitude, and in 1896 Marth added this 20^m to his ephemeris. In consequence of this change, when we wish to compare earlier determinations of longitude with later ones, we must, as above stated, reduce the earlier values by subtracting 4°.8. In Bulletin No. 60 Dr. Lowell says that his observations in 1916 show "the received ephemeris to be 11.73 ± .12 minutes behind time." This corresponds to a difference of longitude of 2°.9.

We must note that before it was the planet that was behind time, now it is the ephemeris. The correction in longitude must therefore be reversed. He accordingly in this bulletin computes a shorter period of rotation than the accepted value, instead of a longer one as he formerly suggested. According to Schiaparelli in 1879, the longitude of Aryn was 0°.9. Correcting this by 4°.8 gives us 356°.1. It appears therefore that in the 15 years between 1879 and 1894 Aryn increased its longitude by 3°.9 or 144 miles, and that during the 20 years between 1894 and 1914 its longitude diminished by 2°.9 or 107 miles. Lowell's latest results therefore very closely confirm Schiaparelli's original position. Indeed his final position differs but 37 miles from that found by the great Italian astronomer 35 years before. It is quite impossible that deviations of 20^m and 12^m should be due to accidental errors, for as Dr. Lowell very truly remarks in referring to the former, it is a quantity "raised well above the possibility of accident, since it is twenty-five times as great as the probable error of the observations."

In Flammarion's Mars I, 506 is given a list of the various determinations of the period of rotation of the planet published prior to 1887. From these Flammarion has selected the six which he considers the best, and takes their mean, arriving at the value $24^h\ 37^m\ 22^s.65$. The extreme values range between $22^s.603$ and $22^s.715$. These values are all based on a comparison of the early drawings of Huyghens and

Maraldi with later observations, the extreme range of dates extending from 1659 to 1881. This value of Flammarion's is the one hitherto used for computing the ephemeris, and is evidently very nearly correct. A shift in position of 1° at the end of 10 years will make a difference in the computed period of $0^s.0754$. An increase of $0^s.02$ in the adopted period to $24^h\ 37^m\ 22^s.67$ would bring Schiaparelli's and Lowell's latest observations into exact agreement, but it is clear that really reliable results will only be obtained by locating several points upon the surface of the planet, instead of using a single one as has been done hitherto.

DOUBLE CANALS.

On several occasions during the past opposition the double effect has been fairly evident here, particularly during the month of March, when the canals were very narrow and often straight. Thus on March 3, ω 335°, $\odot$ 62°.3, seeing 9, magnification 660, Protonilus and Deuteronilus stretched as a strikingly straight narrow band across the disk, and the double effect was clearly seen at intervals. This does not however mean that the canal was clearly double. Such certainly was not the case, but the effect that other observers have described was clearly seen. The canal possessed a geometrical straightness, and a small but perceptible breadth. Once in five or ten seconds it appeared for perhaps half a second to be composed of two extremely sharp and extremely delicate parallel lines. The rest of the time it was a uniform band. One of these appearances was evidently an illusion, the question was which. For several reasons it was concluded that the brief double effect was the illusion, and the band the genuine appearance. Perhaps the most convincing argument (*a*) was derived from this same canal a month later April 7, when it again took on the double appearance. Its breadth was measured at this time by means of the Canal Scale, and was found to be only $0''.13$, or 58 miles. With an 11-inch telescope even two stars must be $0''.41$ apart in order to be separated. Two dark lines require a somewhat greater separation, $0''.58$. Next (*b*) the two lines were separated by a space greater than either of them, such as we are all familiar with in the drawings of double canals. Such defining power is theoretically entirely out of the question with any lens. (*c*) Very good seeing 8 to 10 is absolutely necessary in order to show the double effect, but with our very best seeing 11 to 12, the effect entirely vanishes.

In Lowell Observatory Bulletin No. 5 Dr. Lowell explains how he observed the double canals Euphrates, Hiddekel and Gehon with a 6-inch aperture, and found the separation to be $0''.27$, $0''.26$, and $0''.28$ respectively. From this we gather that the same phenomenon was seen by both observers. In order to separate a real double canal with a 6-inch aperture the separation must be at least 1″.06. He also points out that apertures of 12 and 24 inches gave him approximately the same separation, that with the latter ranging from 0″.35 to 0″.19. In Bulletin No. 15 he states that "The doubles, like all delicate detail, appear not continuously, but by flashes of revelation according as the atmospheric waves permit of passage undisturbed." That is precisely the way they appeared to me. He further states that the breadth of the components is "about a third of the breadth of the light land between them." That is about my impression of them. From these facts it would appear that we both saw the same phenomenon, in spite of the fact that according to my measures the separation was less.

To explain the effect satisfactorily has hitherto proved a very difficult matter. My impression is that it is due to a slight shifting of the image due to the air currents. Usually this shifting is more or less continuous, irregular, and rapid, producing merely a slight blurring of the image. It is believed that occasionally this shifting momentarily becomes fairly regular like a vibration, owing to the action of the atmospheric waves, and that this lasts let us say for half a second or more at a time. We shall then get two images produced side by side. Such an appearance would be visible only for extremely narrow lines, such as are found on Mars, and under such circumstances both images might be distinct even if separated by but little over 0″.1.

The amount of the shift would doubtless be different on different days and at different places, so that uniformity of result is hardly to be expected. In this connection Dr. Lowell's remark "Under faulty visual conditions the doubles appear wider than they otherwise would, for some reason not easy to explain" is of interest. Clearly that is exactly the effect we should expect to find on this hypothesis. See (c) above. We may readily demonstrate the effect mechanically, by viewing an ink line in a vibrating mirror attached to a tuning fork, or more simply by tying a very small mirror to the stem of a T-square placed horizontally, and projecting a few inches over the edge of a table. On setting the mirror in vibration, the reflection of the line, or of a pencil held a few inches above the mirror, will be clearly seen to be doubled.

The writer is not aware that this explanation has been previously proposed, but it seems to him after having studied the appearance with some care, that it accounts satisfactorily for the facts observed with regard to this singular and obscure phenomenon. It certainly appears more plausible than that the canals are really double, and separated by an amount theoretically incapable of detection in the telescope. It is of course possible that wide doubles may exist on Mars like the one on Aristillus. That is however a divergent pair, widely separated at one end. None such have been seen on Mars by the writer as yet, and he believes that if they exist they must be of very rare occurrence. It has been thought best on account of the length of this paper to defer the record of our observations in March and April until the next Report.

PLANET NOTES.

CLIFFORD C. CRUMP.

Occultations Visible at Washington.

Date 1916	Star's Name	Magnitude	IMMERSION.			EMERSION.			Duration	
			Washington M.T.		Angle f'm N.	Washington M.T.		Angle f'm N.		
			h	m	°	h	m	°	h	m
July 16	96 B Aquarii	6.5	18	29	339	18	40	318	0	11
23	17 Tauri	3.8	13	34	25	14	14	297	0	40
23	23 Tauri	4.3	13	56	90	14	54	230	0	58
23	η Tauri	3.0	14	30	76	15	36	243	1	5
23	28 Tauri	5.2	15	23	101	16	23	216	1	1
23	27 Tauri	3.7	15	29	126	16	8	192	0	39
Aug. 7	*b* Scorpii	4.7	7	7	115	8	27	268	1	20
10	127 G Sagittarii	6.4	4	48	61	5	44	292	0	56
10	172 B Sagittarii	5.8	5	46	44	6	38	305	0	52
10	189 B Sagittarii	6.1	8	38	48	9	49	282	1	10
10	208 B Sagittarii	6.1	12	30	69	13	35	246	1	5
12	29 Capricorni	5.5	10	47	61	12	2	235	1	15
13	ρ Aquarii	5.3	15	57	106	16	38	188	0	40
13	170 B Aquarii	6.0	17	44	84	18	34	218	0	50
15	22 Piscium	5.8	7	37	93	8	24	213	0	47
17	101 Piscium	6.2	8	46	75	9	38	235	0	51
24	Saturn	0.4	15	3	104	16	5	272	1	2

Planet Notes for July and August, 1916.

During the months of July and August the sun will move south and east. It will move from Gemini through Cancer, and into Leo. During this interval its declination will change from $+23° 7' 34''.5$, to $+8° 40' 35''.0$. Near the end of August the sun will be near the bright star Regulus. On July 29 there will be an annular eclipse of the sun. This eclipse will be visible in the southern part of Australia and Tasmania.

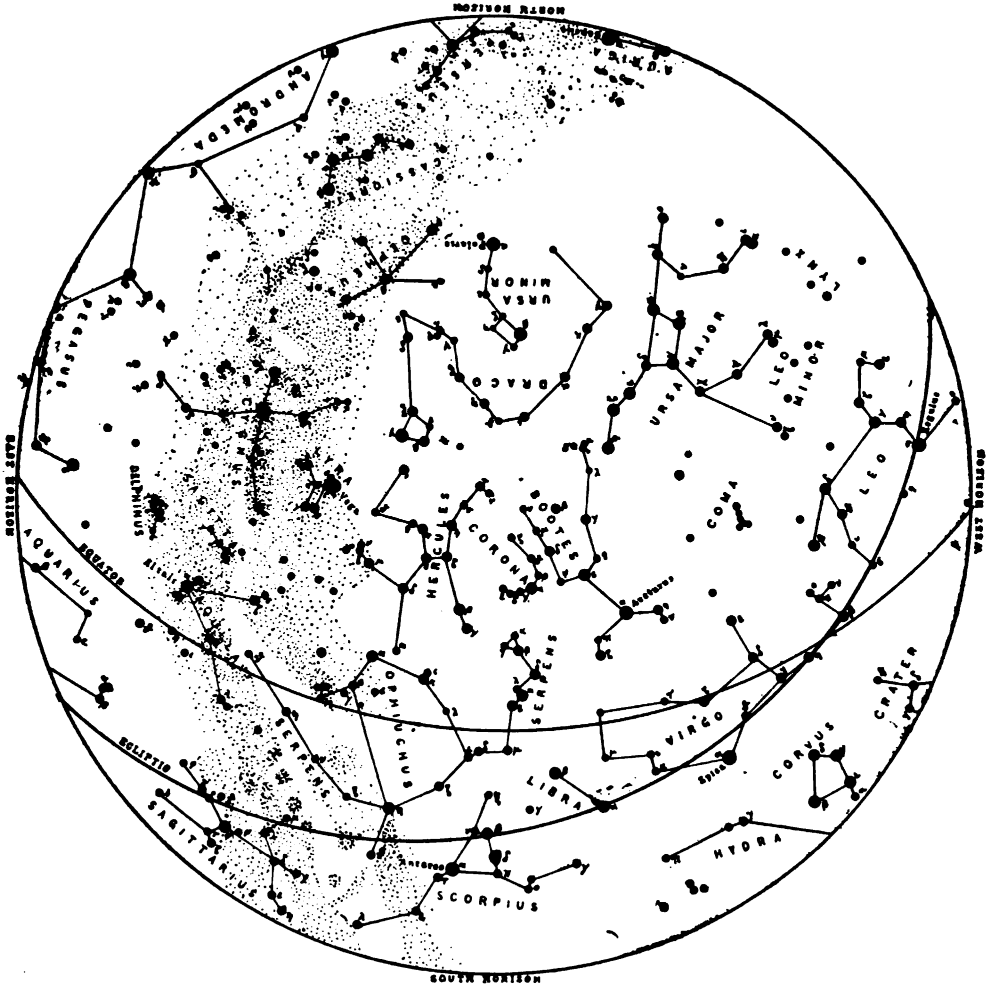
The phases of the moon for July and August are as follows:

			h	m		
First Quarter	July 8	at	5	55.0	A.M.	C.S.T.
Full Moon	14	"	10	40.0	P.M.	"
Last Quarter	21	"	5	33.0	P.M.	"
New Moon	29	"	8	15.4	P.M.	"
First Quarter	Aug. 6	"	3	5.6	A.M.	"
Full Moon	13	"	6	0.3	A.M.	"
Last Quarter	20	"	6	52.8	A.M.	"
New Moon	28	"	11	24.7	A.M.	"

The moon will be at apogee on July 28, and again on August 24. On July 14, and on August 12, it will be at perigee.

Mercury will be found at the beginning of July in the constellation of Taurus. It will have an eastward motion during the two months. It may be seen just before sunrise on July 1.

Venus will move in a retrograde direction in the constellation of Gemini until the first of August, it will then start to move eastward again. On July 3, it will pass between the earth and the sun. During the month of August it will be the bright morning star.



THE CONSTELLATIONS AT 9:00 P. M. JULY 1.

Mars may be observed in the evening sky during the two months. It will move from the constellation of Leo into Virgo.

Jupiter will move eastward in the constellation of Aries until August 22. On this date it will begin to move in a retrograde motion. It may be observed after midnight during the month of August.

Saturn will be behind the sun on July 12. It will be occulted by the moon on August 24. On this date it will be of 0.4 magnitude.

Uranus will be best situated for observation on August 10, being at opposition on this date. It will be found in the constellation of Capricornus.

Neptune will not be visible because of its nearness to the sun.

The Frequency of Striking Conjunctions of Venus and Jupiter. The conjunction of Venus and Jupiter of February, 1916, raised the question of how often such conjunctions can occur. As Venus is never at a greater apparent distance from the sun than about 47°, a conjunction of Venus and Jupiter must occur within that limit, i. e., near conjunction of Jupiter and the Sun. But if a conjunction of the two take place exactly at that time, the retrograde motion of Venus is greater than that of Jupiter, and from this we see that two other conjunctions must take place near that time, one somewhat before and the other after. In this case we would have three conjunctions of Venus and Jupiter in a single synodic revolution of Jupiter. Otherwise there would be but one.

The synodic periods of Venus and Jupiter are very nearly commensurable with each other and with the year, the cycle comprising 155 years, 142 synodic revolutions of Jupiter and 107 of Venus. An investigation shows that if all the orbits were circular and in the same plane, a condition nearly satisfied by Venus, the Earth and Jupiter, three conjunctions of Jupiter and Venus would occur near any one conjunction of Jupiter and the Sun if the interval from this latter to the inferior conjunction of Venus were numerically less than 0.048 year, and that this must occur seven and may occur nine times in the cycle. With this criterion as a guide, a search of the ephemerides showed that there were actually eight such cases. Consequently in 155 years there are 134 conjunctions of Jupiter and the Sun producing one conjunction of Venus and Jupiter each, and eight producing three each, a total of 158.

But while there are 158 conjunctions in 155 years, there are other considerations affecting the interest of the phenomenon. First, approximately half of the conjunctions take place when the planets are morning stars, and are not noticed. Second, the inclinations of the orbit planes to each other and to the ecliptic cause the angular distance between the two bodies at conjunction to vary, sometimes being as much as eight degrees. For the conjunction to be really interesting they should pass within a degree of each other, which occurs about two thirds of the time. For it to be striking, or as close as that of this year, they must pass within half a degree, which occurs about one third of the time. Third, for the conjunction to be easily observable, the planets should be at least 15° from the Sun with ecliptic high, as it is from December to June, or 25° with it low, as it is from June to December. If we set 20° as an average limit we have our condition satisfied two thirds of the time. For the interested observer the distance could be decreased to 15° and the corresponding proportion would become three fourths. The interested observer would also avail himself of the morning conjunctions. And finally, the extreme proximity of the striking conjunctions lasts only a few hours. During this time the planets will be visible to only a part of the earth, being either below the horizon or in daylight for the remainder. The factor arising from this cause is hard to determine but will probably be about one half.

Forming the continued products of the various factors for each condition, we find that about one in two of the conjunctions will be interesting, while but one in eighteen or so will be as striking as that of this year. That is, about one every other year and one every fifteen to twenty years, respectively.

Bernhard H. Dawson.

Ann Arbor, 1916 April 29.

VARIABLE STARS.

The Variable Star *191033* **RY Sagittarii,** is now faint, and observations of its brightness will have much value. Its magnitude is ordinarily 6.5. It was found by Mr. Leon Campbell to be of the eleventh manitude on May 13. It is one of the three variables so far discovered which are bright for a large portion of the time, but occasionally become faint, and vary irregularly. The other two are 054319, SU Tauri, and 154428, R Coronae.

EDWARD C. PICKERING.

Harvard College Observatory,
Bulletin 610.
Cambridge, Mass., U. S. A.
May 17, 1916.

Maxima of Variable Stars of Short Period.

[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. July-August							
	h	m	°	'		d	h	d	h	d	h	d	h	d	h
SX Cassiop.	0	05.5	+54	20	8.6— 9.4	36	13.7			11	20;	17	10		
SY Cassiop.	0	09.8	+57	52	9.3— 9.9	4	1.7	8	14;	24	21;	10	3;	26	10
RR Ceti	1	27.0	+0	50	8.3— 9.0	0	13.3	1	8;	16	19;	1	7;	16	19
RW Cassiop.	1	30.7	+57	15	8.9—11.0	14	19.2	13	12;	28	7;	12	2;	26	22
V Arietis	2	09.6	+11	46	8.3— 9.0	0	23.8	7	1;	22	22;	7	19;	23	16
SU Cassiop.	2	43.0	+68	28	6.5— 7.0	1	22.8	3	21;	19	11;	4	1;	19	16
TU Persei	3	01.8	+52	49	11.4—12.2	0	14.6	2	23;	17	13;	8	9;	30	6
RW Camelop.	3	46.2	+58	21	8.2— 9.4	16	00.0	12		28		13		29	
SX Persei	4	10.2	+41	27	10.4—11.2	4	07.0	9	12;	26	16;	12	20;	29	23
SV Persei		42.8	+42	07	8.8— 9.6	11	03.1	1	23;	24	6;	4	9;	26	15
RX Aurigae	4	54.5	+39	49	7.2— 8.1	11	15.0	2	17;	26	23;	6	14;	29	20
SX Aurigae	5	04.6	+42	02	8.0— 8.7	1	12.8	1	20;	17	4;	1	11;	16	16
SY Aurigae		05.5	+42	41	8.4— 9.5	10	03.3	2	20;	22	2;	11	9;	31	16
Y Aurigae		21.5	+42	21	8.6— 9.6	3	20.6	2	2;	17	12;	1	22;	17	9
RZ Gemin.	5	56.6	+22	15	9.1—10.0	5	12.7	4	11;	21	1;	1	2;	17	16
RS Orionis	6	16.5	+14	44	8.2— 8.9	7	13.6	6	13;	21	17;	5	19;	20	23
T Monoc.		19.8	+7	08	5.7— 6.8	27	00.3	14	19			10	19		
RZ Camelop.		23.7	+67	06	11.0—13.0	0	11.5	8	0;	22	10;	5	20;	20	5
W Gemin.		29.2	+15	24	6.7— 7.5	7	22.0	2	19;	18	15;	3	11;	19	7
ζ Gemin.	6	58.2	+20	43	3.7— 4.3	10	03.7	3	6;	23	14;	2	17;	23	1
RU Camelop.	7	10.9	+69	51	8.5— 9.8	22	06.5	4	14;	26	20;	18	3		
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	5	10;	21	7;	6	4;	22	2
V Carinae	8	26.7	−59	47	7.4— 8.1	6	16.7	7	9;	20	18;	9	20;	29	22

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. July-August							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
T Velorum	8	34.4	−47	01	7.6—8.5	4	15.3	8	18;	27	7;	5	14;	24	3
V Velorum	9	19.2	−55	32	7.5—8.2	4	08.9	8	12;	26	23;	3	17;	21	5
Z Leonis	9	46.4	+27	22	7.9—9.6	59	0.0			25					
RR Leonis	10	02.1	+24	29	9.1−10.1	0	10.9	2	4;	22	13;	5	3;	25	11
SU Draconis	11	32.2	+67	53	8.9—9.6	0	15.8	6	0;	19	5;	1	10;	21	5
S Muscae	12	07.4	−69	36	6.4—7.3	9	15.8	10	4;	29	11;	9	3;	28	10
SW Draconis		12.8	+70	04	8.8—9.6	0	13.7	8	10;	24	9;	1	8;	17	7
T Crucis		15.9	−61	44	6.8—7.6	6	17.6	1	22;	22	2;	11	7;	31	12
R Crucis		18.1	−61	04	6.8—7.9	5	19.8	5	7;	22	18;	3	10;	20	21
S Crucis	12	48.4	−57	53	6.5—7.6	4	16.6	3	18;	22	12;	5	14;	24	8
W Virginis	13	20.9	−2	52	8.7—10.4	17	06.5	5	4;	22	11;	8	17;	26	0
SS Hydrae		25.0	−23	08	7.4—8.1	8	4.8	7	10;	23	19;	9	5;	25	14
RV Urs. Maj.	13	29.4	+54	31	9.2—9.9	0	11.2	3	22;	17	23;	1	0;	22	1
ST Virginis	14	22.5	−0	27	10.3—11.4	0	09.9	4	21;	21	7;	6	17;	23	3
V Centauri		25.4	−56	27	6.4—7.8	5	11.9	7	9;	18	9;	3	20;	25	20
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	5	10;	20	12;	4	14;	19	16
RU Bootis	14	41.5	+23	44	12.8—14.3	0	11.9	8	9;	23	5;	7	1;	21	20
R Triang. Austr.	15	10.8	−66	08	6.7—7.4	3	09.3	2	21;	23	5;	5	18;	19	8
S Triang. Austr.	15	52.2	−63	29	6.4—7.4	6	07.8	4	8;	23	7;	4	23;	23	22
S Normae	16	10.6	−57	39	6.6—7.6	9	18.1	1	18;	21	6;	9	18;	29	6
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	3	6;	20	23;	7	16;	25	9
RV Scorpii	16	51.8	−33	27	6.7—7.4	6	01.5	6	21;	19	0;	6	4;	24	9
X Sagittarii	17	41.3	−27	48	4.4—5.0	7	00.3	5	2;	19	3;	9	4;	30	5
Y Ophiuchi		47.3	−6	07	6.1—6.5	17	02.9	10	10;	27	12;	14	15;	31	18
W Sagittarii	17	58.6	−29	35	4.3—5.1	7	14.3	1	3;	23	21;	8	2;	23	7
Y Sagittarii	18	15.5	−18	54	5.4—6.2	5	18.6	1	10;	18	18;	5	1;	22	9
U Sagittarii		26.0	−19	12	6.5—7.3	6	17.9	7	13;	21	1;	3	13;	23	18
Y Scuti		32.6	−8	27	8.7—9.2	10	08.3	11	5;	31	21;	10	30;	21	14
Y Lyrae		34.2	+43	52	11.3—12.3	0	12.1	5	14;	23	16;	10	19;	28	21
RZ Lyrae	18	39.9	+32	42	9.9—11.2	0	12.3	6	14;	25	0;	12	10;	30	20
RT Scuti	18	44.1	−10	30	9.1—9.7	0	11.9	2	21;	20	18;	7	14;	31	9
κ Pavonis	18	46.6	—67	22	3.8—5.2	9	02.2	3	0;	21	4;	6	9;	25	13
U Aquilae	19	24.0	−7	15	6.2—6.9	7	00.6	5	8;	19	9;	9	11;	30	12
XZ Cygni		30.4	+56	10	8.6—9.3	0	11.2	5	5;	19	5;	2	5;	23	5
U Vulpec.		32.2	+20	07	6.5—7.6	7	23.5	2	3;	18	2;	3	1;	19	0
SU Cygni		40.8	+29	01	6.2—7.0	3	20.3	3	0;	18	10;	2	19;	18	4
η Aquilae		47.4	+0	45	3.7—4.5	7	04.2	4	3;	18	12;	9	0;	30	13
S Sagittae		51.5	+16	22	5.6—6.4	8	09.2	1	21;	18	15;	4	9;	29	13
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	1	23:	20	22;	8	21;	27	20
X Cygni	20	39.5	+35	14	6.0—7.0	16	09.3	9	5;	25	14;	11	0;	27	9
T Vulpec.		47.2	+27	52	5.5—6.1	4	10.5	3	18;	17	2;	3	20;	21	13
WY Cygni		52.3	+30	03	9.6—10.4	0	13.5	2	17;	22	21;	12	2;	25	13
RV Capric.		55.9	−15	37	9.2—10.1	0	10.7	1	18;	21	22;	11	1;	31	5
TX Cygni	20	56.4	+42	12	8.5—9.7	14	17.4	3	10;	18	3;	1	20;	31	7
VY Cygni	21	00.4	+39	34	8.8−9.5	7	20.6	2	5;	17	22;	2	15;	18	10
SW Aquarii		10.2	—0	20	9.9−10.8	0	11.0	5	12;	19	7;	8	23;	29	15
VZ Cygni	21	47.7	+42	40	8.2−9.2	4	20.7	4	23;	19	14;	3	4;	17	18
Y Lacertae	22	05.2	+50	33	9.1−9.6	4	07.8	5	3;	22	10;	8	18;	26	1
δ Cephei		25.5	+57	54	3.7−4.6	5	08.8	5	3;	21	5;	6	8;	22	10
Z Lacertae		36.9	+56	18	8.2−9.0	10	21.1	9	0 ;	30	18;	10	15;	21	12
RR Lacertae		37.5	+55	55	8.5−9.2	6	10.1	1	10;	14	6;	2	12;	21	18
V Lacertae	22	44.5	+55	48	8.5—9.5	4	23.6	1	13;	26	12;	5	10;	20	9
SW Cassiop.	23	03.7	+58	11	9.2—9.7	5	10.6	6	11;	22	18;	8	2;	24	10
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	2	17;	21	14;	9	12;	28	9
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4	1	1;	25	7;	6	11;	30	18
V Cephei	23	51.7	+82	38	6.0—7.0	0	23.6	1	7;	21	6;	10	5;	30	4

Minima of Variable Stars of Short Period.

[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1916 July-August
	h m	° ′		d h	d h d h d h d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	1 19
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	4 8; 19 16; 4 0; 19 9
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	1 2; 23 9; 7 6; 22 3
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	5 6; 20 5; 4 4; 19 3
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	7 21; 26 5; 7 10; 19 16
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	2 17; 24 3; 7 10; 21 16
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	6 9; 20 3; 2 20; 23 10
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	6 3; 20 12; 3 20; 18 4
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	9 11; 27 1; 4 19; 22 9
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	8 21; 24 18; 1 17; 19 14
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	20 20 22 4
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	3 10; 21 15; 2 2; 19 6
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	4 13; 18 4; 7 13; 21 3
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	3 7; 19 2; 3 22; 19 17
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	2 4; 18 19; 4 10; 21 1
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	8 0; 23 19; 8 14; 24 9
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	2 15; 29 0; 11 5; 24 10
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	5 19; 24 16; 3 3; 22 0
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	7 19; 20 5; 1 15; 26 11
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	6 16; 20 0; 2 8; 22 8
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	1 6; 17 15; 2 23; 19 9
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	6 0; 24 2; 5 3; 23 4
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	4 14; 21 22; 8 6; 25 14
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	9 4; 30 0; 9 10; 19 19
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	5 15; 21 16; 6 17; 22 17
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	5 16; 22 21; 3 8; 20 13
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	4 10; 21 5; 1 10; 18 5
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	1 3; 17 12; 2 22; 19 8
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	5 14; 20 20; 5 2; 20 8
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	1 12; 25 23; 7 3; 19 8
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	4 12; 18 20; 2 4; 23 16
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	1 22; 20 2; 7 6; 16 8
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	2 7; 20 21; 8 12; 17 19
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	11 0; 31 7; 10 4; 20 3
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	4 15; 20 10; 6 5; 23 0
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	1 22; 14 18; 9 11; 22 8
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	5 0; 19 13; 3 2; 17 16
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	9 3; 25 8; 2 11; 18 17
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	6 1; 25 0; 3 12; 22 11
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	2 1; 20 7; 7 13; 16 16
S Antliae	27.9	−28 11	6.7— 7.3	0 07.8	5 3; 8 2; 6 12; 19 12
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	4 16; 16 13; 3 8; 21 3
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	2 12; 19 8; 5 5; 22 2
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	3 3; 21 16; 9 5; 18 12
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	7 11; 20 16; 2 21; 22 16
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	8 19; 26 10; 4 5; 21 19
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	1 14; 16 7; 7 7; 21 22
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	4 5; 24 12; 7 3; 20 16
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	4 8; 19 8; 3 8; 18 8
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	10 12; 29 16; 8 7; 17 21
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	2 23; 17 20; 1 17; 16 14
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	5 23; 19 22; 2 21; 16 20

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 July-August							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
U Coronae	15	14.1	+32	01	7.6—8.7	3	10.9	4	11;	18	6;	1	1;	21	18
TW Draconis		32.4	+64	14	7.3—8.9	2	19.4	8	12;	25	8;	2	18;	19	14
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	2	20;	18	4;	2	11;	17	19
SW Ophiuchi	16	11.1	—6	44	9.2—10.0	2	10.7	2	11;	24	11;	8	4;	22	20
SX Ophiuchi		12.6	—6	25	10.5—11.2	2	01.5	7	18;	24	6;	1	12;	18	0
R Arae		31.1	—56	48	6.8—7.9	4	10.2	7	7;	25	0;	2	20;	20	13
TT Herculis	16	49.9	+17	00	8.9—9.3	20	18.1	4	4;	24	22;	3	14;	14	16
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	1	10;	21	19;	4	10:	18	1
U Ophiuchi		11.5	+1	19	6.0—6.7	0	20.1	2	15;	19	9;	5	4;	21	22
u Herculis		13.6	+33	12	4.6—5.4	2	01.2	5	17;	24	4;	5	11;	17	18
TX Herculis		15.4	+42	00	8.3—9.0	1	00.7	5	21;	20	8;	3	18;	18	4
RV Ophiuchi		29.8	+7	19	9. —12	3	16.5	6	12;	21	6;	5	0;	19	18
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	2	16;	19	1;	4	9;	20	18
TX Scorpii		48.6	—34	13	7.5—8.2	0	22.6	5	3;	20	1;	4	7;	19	9
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	2	9;	17	21;	2	8;	17	20
Z Herculis		53.6	+15	09	7.1—7.9	3	23.8	6	22;	22	21;	7	20;	23	20
WX Sagittae		53.6	—17	24	9.2—10.8	2	03.1	1	11;	18	12;	4	13;	21	14
WY Sagittae	17	54.9	—23	1	9.5—10.6	4	16.0	4	22;	23	15;	1	23;	20	15
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	5	21;	26	13;	5	22;	26	14
RS Sagittarii		11.0	—34	08	5.9—6.3	2	10.0	7	16;	22	4;	5	16;	20	4
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	1	22;	22	15;	5	11;	19	6
RZ Scuti		21.1	—9	15	7.4—8.3	15	03.2	1	17;	31	22;	16	2;	31	5
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	9	0;	25	13;	2	19;	19	8
RX Herculis		26.0	+12	32	7.0—7.6	0	21.3	4	11;	22	5;	9	0;	26	19
SX Sagittarii		39.7	—30	36	8.7—9.8	2	01.8	2	4;	18	18;	4	9;	21	0
RR Draconis		40.8	+62	34	9.3—13	2	19.9	7	11;	24	11;	1	23;	18	22
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	6	7;	19	14;	1	21;	21	19
β Lyrae		46.4	+33	15	3.4—4.1	12	21.8	4	13;	30	9;	13	6;	26	4
U Scuti	18	48.9	—12	44	9.1—9.6	0	22.9	3	6;	22	8;	10	11;	19	23
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	3	8;	18	11;	2	15;	17	18
RV Lyrae		12.5	+32	15	11. —12.8	3	14.4	4	12;	18	22;	2	7;	16	17
RS Vulpec.		13.4	+22	16	6.9—8.0	4	11.4	9	1;	26	23;	4	22;	22	20
U Sagittae		14.4	+19	26	6.5—9.0	3	09.1	3	13;	23	20;	6	8;	19	21
Z Vulpec.		17.5	+25	23	7.3—8.5	2	10.9	4	14;	19	7;	3	1;	17	18
TT Lyrae		24.3	+41	30	9.3—11.6	5	05.8	4	6;	14	18;	4	17;	21	11
UZ Draconis		26.1	+68	44	9.0—9.8	1	15.1	5	2;	24	16;	6	17;	19	18
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	3	13;	21	13;	2	14;	20	14
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	3	19;	23	17;	5	23;	19	5
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	7	23;	26	6;	4	9;	22	16
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	7	18;	24	14;	2	1;	18	21
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	3	0;	23	8;	2	1;	22	8
UW Cygni		19.6	+42	55	10.5—10.8	3	13	1	7;	22	0;	4	20;	18	16
V Vulpec.		32.3	+26	15	8.2—9.8	37	19.0			14	14			21	9
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	3	3;	22	8;	10	14;	20	4
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	8	8;	26	18;	4	23;	23	9
Y Cygni		48.1	+34	17	7.1—7.9	1	12.0	6	12;	21	11;	5	11;	20	10
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	5	1;	22	14;	3	6;	20	19
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	9	23;	30	5;	9	6;	19	9
VV Cygni	21	02.3	+45	23	12.1—13.8	1	11.4	6	20;	21	14;	5	9;	20	3
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	9	9;	28	18;	7	10;	17	3
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	1	14;	17	7;	2	1;	17	19
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3			20	10			20	17
RT Lacertae	21	57.4	+43	24	9.1—10.5	5	01.7	2	17;	23	0;	2	4;	22	11
RW Lacertae	22	40.6	+49	08	10.2—11.2	5	04.4	2	15;	18	4;	2	16;	17	6
X Lacertae	22	45.0	+55	54	8.2—8.6	5	10.6	3	9;	19	17;	5	1;	21	9
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.3	2	23;	19	13;	5	3;	21	17
Y Piscium		29.3	+7	22	9.0—12.0	3	18.4	3	0;	18	1;	2	3;	17	4
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	8	0;	24	12;	1	18;	18	5

COMET AND ASTEROID NOTES.

A New Comet.—On May 1 a telegram was received at the Harvard College Observatory from Copenhagen, announcing the discovery of a planet by Wolf at Heidelberg on April 27. This object has since been found to be a comet, and has been observed at those observatories having large telescopes. The following positions have been reported through the Harvard Circulars:

	α	δ		
	h m s	° ″		
May 4.8565	12 36 55.6	+2 59 51	Van Biesbroeck	Yerkes Observatory
6.6559	12 36 10.3	3 7 46	Barnard	Yerkes "
6.6846	12 36 9.5	3 7 53	Burton	U. S. Naval "
10.6331	12 34 36.0	3 24 13	Barnard	Yerkes "

An orbit of this comet has been computed by Mr. Van Biesbroeck at the Yerkes Observatory. The elements are given as follows:

Time of perihelion passage	(T)	1918, July 27, G.M.T.
Perihelion minus node	(ω)	162° 40′
Longitude of node	(Ω)	187 12
Inclination	(i)	40 9
Perihelion distance	(q)	1.516

The positions have been computed for a few dates. We give those which may still be of use to our readers.

	α	δ
	h ′ ″	° ′
June 1	12 29 16	+4 31
5	12 28 49	4 38

At the time of discovery the comet was within 26° of aphelion. It has a period of 7.81 years, an eccentricity of 0.6147, and semi-major axis, 3.936.

Elements of Taylor's Comet, (1915 *e*).—I am sending you my latest elements of Taylor's Comet based upon three normals from observations taken first week of December 1915, and first weeks of January and February 1916. On March 18, 1916 $13^h\ 40^m\ 5^s$ G.M.T., Professor Barnard of Yerkes Observatory observed the comet in the following position: $\alpha = 6^h\ 47^m\ 19^s.14$, $\delta = +\ 32°\ 16'\ 0''.40$. These elements give the following position for the same time: $\alpha = 6^h\ 47^m\ 9^s.72$, $\delta = +\ 32°\ 16'\ 9.''40$. Fairly good.

Geocentric position (normals) that the elements are based on.

	° ′ ″	° ′ ″
1915 t = Dec. 7.7719	λ = 79 41 34.46	β = − 22 53 33.44
1916 t' = Jan. 8.6177	λ' = 76 36 22.52	β' = − 12 10 37.14
t'' = Feb. 9.5742	λ'' = 82 33 10.06	β'' = + 0 27 40.59

° ′ ″	
☉ = 255 4 43.00	Log R = 9.993434
☉′ = 287 31 39.47	" R' = 9.992715
☉″ = 320 0 33.02	" R'' = 9.994218

° ′ ″	° ′ ″
Ψ' = 146 59 22.56	z' = 19 48 36.21

ELEMENTS.

Epoch = Jan. 8.6177 G.M.T., 1916.

$$M = 356^\circ\ 40'\ 17''.21$$
$$\omega = 354\ \ 50\ \ \ 2\ .12$$
$$\pi = 108\ \ 36\ \ 27\ .60$$
$$\Omega = 113\ \ 46\ \ 25\ .48$$
$$i = 15\ \ 40\ \ \ 5\ .42$$
$$\log a = 0.547050$$
$$\log e = 9.745211$$
$$\log q = 0.194270$$
$$\mu = 536''.3251$$

Heliocentric positions from fifth and last hypothesis.

$$l = 76^\circ\ 54'\ 55''.65 \qquad b = -\ 9^\circ\ 33'\ \ 1''.48$$
$$l' = 95\ \ 19\ \ 29.15 \qquad b' = -\ 5\ \ 4\ \ 20.76$$
$$l'' = 114\ \ 36\ \ 37.96 \qquad b'' = +\ 0\ \ 14\ \ \ 4.93$$

$$\log r = 0.219655 \qquad u = 322^\circ\ \ 5'\ 42''.47$$
$$\text{"}\ \ r = 0.198869 \qquad u' = 340\ \ 53\ \ 23.37$$
$$\text{"}\ \ r = 0.195130 \qquad u'' = 0\ \ 52\ \ \ 8.72$$

CONSTANTS.

$$x = r\ (9.986314)\ \sin\ (204^\circ\ 35'\ \ 3''.65 + u)$$
$$y = r\ (9.981829)\ \sin\ (118\ \ 54\ \ 21.24 + u)$$
$$z = r\ (9.575159)\ \sin\ (\ 75\ \ 38\ \ \ 8.01 + u)$$

F. E. SEAGRAVE.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Apr.-May, 1916.

The marked increase in the number of observations contributed this month is most gratifying, and we submit this month the best report of the year thus far.

Mr. Bancroft leads with a good list of 228 observations, many of them early morning observations, which have a special value. Messrs. Eaton and McAteer deserve mention for lists of great merit contributed to this report.

It is a pleasure to welcome as a new member of the Association Mr. Paul S. Yendell, of 19 Winter St., Dorchester, Mass., an eminent authority on variables, the discoverer of many of them, and one of the pioneer variable star observers in this country. Mr. Yendell honors the Association in applying for membership, and kindly offers to assist any of our members who desire special information respecting variable stars. Observations contributed by Mr. Yendell to the reports will be indicated by the Greek capital letter upsilon "Υ". Messrs. Miner, "Mr" and Whitehorn, "Wh" join the ranks of active observers this month, and contribute to this report.

We regret to announce that Mr. Spinney has been obliged to discontinue the observation of variables for the time being. Mr. Spinney has rendered the Association valuable and faithful service, and we shall miss his participation in the reports.

VARIABLE STAR OBSERVATIONS Apr.-May, 1916.

001755
T Cassiop.

J.D.	Est.	Obs.
242		
0956.6	8.8	Bu
73.6	9.3	Pi

004958
W Cassiop.

0956.6	9.4	Bu
71.6	9.0	Ba
73.6	9.0	Bu

012350
RZ Persei

0956.6	9.5	Bu
73.6	9.4	Bu

014958
X Cassiop.

0956.6	9.6	Bu
59.6	10.1	Y
73.6	9.5	Bu
74.6	10.0	Y
88.5	9.6	Y

015354
U Persei

0956.6	9.2	Bu
63.6	8.9	V
73.6	9.4	Bu

021024
R Arietis

0949.6	8.2	R

021281
Z Cephei

0963.6	<11.5	V

021558
S Persei

0956.6	9.3	Bu
61.7	9.6	R
69.6	9.1	Ba

022150
RR Persei

0974.5	<12.4	Y

023133
R Triang.

0949.6	7.0	R

024356
W Persei

0956.5	10.0	O
56.6	10.2	Bu
61.6	10.4	R
69.6	9.3	Ba
74.5	9.8	Ba
83.6	9.6	Ba

032043
Y Persei

0956.6	9.5	Bu
61.7	8.5	R
69.6	8.5	Ba
74.5	8.6	Ba

032335
R Persei

J.D.	Est.	Obs.
242		
0969.6	9.2	Ba
74.5	8.9	Ba

033362
U Camelop.

0956.6	7.5	Bu
69.6	7.2	Ba
74.5	7.4	Ba
83.6	8.2	Pi
84.6	7.2	Ba

042215
W Tauri

0972.6	11.0	M

043065
T Camelop.

0956.6	8.4	Bu
71.6	8.5	Ba
73.6	8.2	Bu
76.6	8.0	M
82.7	8.2	M
83.6	8.6	Pi
84.6	8.2	Ba

043274
X Camelop.

0949.7	8.5	R
56.5	8.2	O
56.6	8.3	Bu
59.5	8.2	O
59.6	8.5	Cr
60.6	8.8	Cr
63.6	8.9	V
64.5	8.7	O
64.6	8.5	Ba
64.6	8.4	Cr
69.6	9.0	Ba
71.6	9.0	Ba
72.6	9.3	Pi
73.5	9.5	O
73.6	9.1	Bu
73.6	9.6	Y
74.6	9.6	O
74.6	9.3	Ba
79.7	9.8	M
81.6	10.2	Cr
82.7	10.2	M
83.6	10.8	Pi
83.6	10.3	Ba
84.5	10.4	O
88.5	11.3	Y

050953
R Aurigae

0949.7	9.0	R
56.6	8.3	Bu
58.6	8.7	M
69.6	8.5	Ba
74.5	8.5	Ba
83.6	8.8	Pi
83.6	8.5	Ba

052034
S Aurigae

J.D.	Est.	Obs.
242		
0956.6	8.8	Bu
69.6	8.8	Ba
74.6	8.8	Ba
83.6	8.9	Ba

052036
W Aurigae

0969.6	10.4	Ba
74.6	9.8	Ba
74.6	10.3	Y
83.6	9.6	Ba

053068
S Camelop.

0973.6	9.7	Y

053531
U Aurigae

0974.6	<12.7	Y

054319
SU Tauri

0956.6	9.5	E
56.5	9.4	O
56.6	9.3	Bu
59.5	9.5	O
62.6	9.6	E
63.6	9.5	V
69.6	9.1	Ba
73.5	9.4	O
74. 6	9.4	Ba
74.6	9.7	Y
83.6	9.5	Ba

054615
RU Tauri

0974.6	<12.5	Y

054615
Z Tauri

0974.6	<12.0	Y

054920
U Orionis

0956.5	9.7	O
56.6	10.0	Bu
71.6	8.9	Ba
72.6	9.6	M
73.5	9.3	O

054974
V Camelop.

0958.6	<10.9	M
64.5	12.0	Ba
72.6	<10.9	M
73.6	12.3	Y
74.7	<10.9	M
79.7	<10.9	M
82.7	<10.9	M
82.6	12.8	B
83.6	<11.6	Pi
83.6	<12.8	Ba
88.5	12.4	Y

055353
Z Aurigae

J.D.	Est.	Obs.
242		
0956.6	9.8	Bu
69.6	10.5	Ba
72.6	10.7	M
74.6	10.5	Y
83.6	10.7	Pi
83.6	10.6	Ba

060450
X Aurigae

0955.6	10.4	E
56.6	10.9	Bu
69.6	10.0	Ba
73.6	10.5	Bu
73.6	9.8	Y
74.6	10.1	Ba
83.6	9.2	Pi
83.6	9.0	Ba

060547
SS Aurigae

0955.6	<12.6	E
56.6	<10.8	O
62.6	<11.6	E
63.6	11.1	V
64.6	10.7	Ba
66.6	12.0	Ba
69.6	<12.5	Ba
71.6	<12.0	Ba
72.6	<10.8	M
73.5	<10.8	O
73.6	<13.3	Y
74.6	<12.0	Ba
82.5	<13.0	B
83.6	<13.3	Ba
84.4	<13.3	Ba
88.6	<13.3	Ba

061647
V Aurigae

0956.6	<11.1	Bu
73.6	<11.1	Bu
84.6	11.6	Ba

061702
V Monoc.

0956.6	9.8	Bu

063159
U Lyncis

0956.6	<10.7	Bu
69.6	13.6	Ba
73.6	<10.7	Bu
73.6	<13.1	Y
83.6	13.6	Ba

063558
S Lyncis

0955.6	12.7	E
73.6	<12.6	Y

064030
X Gemin.

J.D.	Est.	Obs.
242		
0955.7	<11.7	E
69.6	12.0	Ba
74.6	11.8	Ba
83.6	11.3	Ba

064932
Nova. Gemin. 2

0955.7	13.2	E

065111
Y Monoc.

0955.7	12.3	E

065208
X Monoc.

0956.6	7.4	Bu
61.6	7.2	R
69.6	8.3	Ba
73.6	7.6	Bu
75.7	7.6	R
83.6	8.7	Ba

065355
R Lyncis

0949.7	7.8	R
56.6	8.3	Bu
73.6	8.8	Y
75.7	9.6	R

070122a
R Gemin.

0956.6	<11.1	Bu
8.4	<12.5	Nt

070122
TW Gemin.

0956.6	8.2	Bu
75.7	8.5	R
84	8.3	Nt

070122b
Z Gemin.

0956.6	<11.1	Bu

070310
R Can. Min.

0956.6	9.5	Bu
59.5	9.4	O
69.6	8.5	Ba
73.5	8.9	O
83.6	8.3	Ba

071713
V Gemin.

0969.6	10.9	Ba
71.6	10.5	Ba
74.6	10.8	Y
83.6	10.1	Ba

VARIABLE STAR OBSERVATIONS Apr.-May, 1916—Continued.

072708
S Can. Min.

J.D.	Est.	Obs.
242		
0956.6	10.4	Bu
58.6	10.6	M
60	10.8	Mu
62.7	8.3	R
69.6	11.4	Ba
83.6	11.6	Ba

073508
U Can. Min.

0952.6	9.6	R
56.6	9.2	Bu
58.6	9.6	M
59.5	9.5	O
69.6	9.5	Ba
73.5	9.7	O
74.6	9.7	Y
83.6	9.7	Ba
84.6	9.8	O

073723
S Gemin.

0963.6	<10.8	V
82.6	11.7	B

074922
U Gemin.

0955.6	<12.4	E
56.6	<11.4	O
62.6	<12.4	E
63.6	<11.4	V
69.6	<13.3	Ba
72.6	<11.4	M
73.5	<10.9	O
74.6	<12.6	Y
74.6	<10.9	O
74.7	<10.9	M
79.7	<11.4	M
82.6	<13.5	B
83.6	<10.9	O
83.6	<13.7	Ba
84	<12.4	Nt
84.6	<10.9	O
84.6	<13.3	Ba
85.6	<10.0	O
88.6	<13.3	Y

081112
R Cancri

0952.7	9.2	R
58.6	8.3	Bu
69.6	7.7	Ba
73.6	8.4	O
73.6	8.1	Bu
74.6	8.5	Pi
75.7	8.6	R
83.6	8.4	O
83.6	7.4	Ba

081617
V Cancri

J.D.	Est.	Obs.
242		
0952.7	8.8	R
58.6	9.0	Bu
69.6	9.2	Ba
73.6	9.6	O
73.6	9.4	Bu
83.6	9.9	Ba
84.6	10.0	O

082405
RT Hydrae

0958.6	8.2	Bu
84.6	7.5	Ba

083019
U Cancri

0955.6	<12.9	E
84.6	<12.5	Ba

084803
S Hydrae

0958.6	<10.2	Bu

085008
T Hydrae

0956.5	<10.0	O
58.6	<9.9	Bu

085120
T Cancri

0984.6	9.4	Ba

090151
V Urs. Maj.

0949.6	10.4	R
52.6	10.6	R
53.7	10.2	R
56	9.9	Mu
60	9.8	Mu
61.7	10.6	R
62.7	10.4	R
63.6	9.5	V
69.6	10.0	Ba
75.7	10.3	R
76.7	10.5	R
76	9.8	Mu
81	9.7	Mu
83.6	10.1	Ba

090425
W Cancri

0969.6	12.2	Ba
83.6	11.3	Ba

093014
X Hydrae

0952.7	9.0	R
58.6	9.3	Bu
84.6	10.2	Ba

093178
Y Draconis

0974.6	10.6	Y

093934
R Leo. Min.

J. D.	Est.	Obs.
242		
0953.6	8.4	R
58.6	9.0	Bu
69.6	8.4	Ba
74.6	9.0	Pi
83.6	8.9	Ba

094211
R Leonis

0953.6	9.3	R
55.7	9.0	E
56	9.4	Mu
58.6	9.6	Bu
59.5	9.9	O
60	9.4	Mu
63	9.4	Mu
69.7	8.9	Ba
73.6	9.7	Bu
73.6	9.6	O
74.6	9.8	M
74.6	9.8	Pi
74	9.3	Mu
76	9.4	Mu
81	9.4	Mu
83.6	9.7	O
83.6	8.9	Ba

094622
Y Hydrae

0953.7	7.0	R
58.6	6.8	Bu
75.7	7.5	R
84.6	6.5	Ba

095421
V Leonis

0982.6	<13.5	B
83.6	<13.6	Ba

103212
U Hydrae

0953.7	5.3	R
75.7	4.8	R

103769
R Urs. Maj.

0958.6	11.4	M
60	11.1	Mu
69.7	11.3	Ba
73.5	11.7	Pi
74.6	11.5	Ba
83.6	12.0	Ba

104620
V Hydrae

0953.7	7.7	R
58.6	6.6	Bu
75.7	7.7	R
84.6	6.0	Ba

104814
W Leonis

0982.6	<13.4	B

115919
R Comae

J.D.	Est.	Obs.
242		
0964.5	<10.0	O
69.6	<12.0	Ba
72.5	<11.0	Pi
74.6	<13.0	Ba

120012
SU Virginis

0958.7	10.4	Bu
64.6	9.0	O
64.6	9.9	Ba
71.6	9.3	Ba
79.7	9.0	M
83.6	9.0	Ba

120905
T Virginis

0958.7	10.8	Bu
63.6	10.3	V
64.6	10.3	Ba
79.7	11.4	M
83.6	10.8	Ba
88.6	11.4	Y

121418
R Corvi

0953.7	7.5	R
58.7	7.3	Bu
59.0	7.2	Ho
64.6	7.0	Ba
71.6	7.1	Ba
75.7	8.0	R
79.7	7.5	M
83.6	8.0	Ma
83.6	7.4	Ba
84	7.5	Nt

122001
SS Virginis

0958.7	8.3	Bu
64.6	8.6	O
64.6	7.8	Ba
71.6	7.5	Ba
79.7	9.4	M
83.6	8.0	Ba

122303
V Virginis

0959.0	9.0	Ho

122532
T Can. Ven.

0956.6	9.7	O
58.7	10.0	Bu
64.5	9.7	O
64.6	9.5	Ba
71.6	9.2	Ba
74.6	9.5	Pi
74.6	9.6	M
82.7	9.8	M
84.6	9.4	Ba

122802
Y Virginis

J.D.	Est.	Obs.
242		
0959.0	12.0	Ho
64.6	<12.0	Ba
74.6	<12.2	Ba
82.6	13.0	B

123160
T Urs. Maj.

0955.6	11.5	E
58.7	11.2	Bu
64.6	10.0	Ba
69.7	9.4	Ba
72.6	8.9	M
73.5	9.4	Pi
74.6	8.8	M
74.6	9.0	Ba
74	9.3	Mu
76	9.1	Mu
80.8	8.6	E
83.6	8.4	Ba
85.6	8.6	O
93.6	8.1	O

123307
R Virginis

0958.7	10.9	Bu
64.6	10.6	Ba
74.6	9.9	Ba
79.7	9.4	M
80.8	9.2	E
83.6	9.0	Ba
85.6	9.0	O
90.7	8.6	O
90.7	8.5	Pi
90.7	8.1	Ba
90.7	8.0	C
93.6	8.2	O

123459
RS Urs. Maj.

0974	10.5	Mu
76	10.1	Mu
83.6	<13.3	Ba

123961
S Urs. Maj.

0955.6	10.1	E
56.5	10.0	O
58.6	10.0	M
58.7	10.0	Bu
64.6	10.4	Ba
69.6	10.5	Ba
72.6	10.7	M
73.5	10.6	Pi
74.6	11.0	Ba
74	10.6	Mu
76	10.4	Mu
80.8	11.0	E
83.6	11.2	Ba

VARIABLE STAR OBSERVATIONS Apr.-May, 1916—Continued.

124204
RU Virginis

J.D.	Est.	Obs.
242		
0974.6	<12.8	Ba
82.6	<13.3	B

124606
U Virginis

0958.7	8.3	Bu
64.6	8.8	O
64.6	8.6	Ba
73.6	8.7	O
74.6	8.4	Ba
79.7	8.5	M
83.6	8.6	Ba
83.8	8.7	Pi
84.6	8.7	O
93.6	8.7	O

132002
W Virginis

0979.7	10.1	M

132202
V Virginis

0974.6	8.8	Ba
79.7	9.8	M
84.6	8.8	Ba

132422
R Hydrae

0981.0	7.8	Mu

132706
S Virginis

0964.6	9.9	Ba
74.6	10.9	Ba
79.7	10.8	M
83.6	10.7	Y
84.6	11.2	Ba

134440
R Can. Ven.

0958.6	8.9	M
58.7	9.0	Bu
59.5	9.1	O
64.5	9.6	O
64.6	9.1	Ba
71.6	9.1	Ba
72.6	9.5	M
73.6	10.0	O
80.8	9.8	E
82.7	9.8	M
83.6	10.1	Ba

135908
RR Virginis

0979.7	<11.8	M

141567
U Urs. Min.

0964.6	10.4	Ba
71.6	10.4	Ba
73.6	10.8	Pi
83.6	10.5	Ba

141954
S Bootis

J.D.	Est.	Obs.
242		
0964.6	11.6	Ba
71.6	11.2	Ba
83.6	10.6	Ba

142205
RS Virginis

0974.6	11.6	Ba

142539
V Bootis

0958.7	9.9	Bu
59.5	9.8	O
64.6	9.3	Ba
71.6	9.0	Ba
72.6	9.1	Pi
73.6	9.7	O
74.6	9.2	M
83.6	9.0	Ba
84.6	9.4	O
93.6	9.3	O

142584
R Camelop.

0956.5	9.1	O
59.5	9.0	O
64.5	9.0	O
73.5	8.4	O
76.7	9.0	R
83.6	8.4	O
84.6	8.3	Ba
93.6	8.1	O

143227
R Bootis

0974.6	11.1	O
74.6	<11.2	M
74.6	11.1	Ba
83.6	9.8	Ba
84.6	10.1	O
93.6	9.2	O

144918
U Bootis

0963.6	10.7	V
74.7	10.7	M
74.6	10.8	Ba
84.6	11.1	Ba

150018
RT Librae

0958.0	<12.6	Ho
83.7	<13.0	Ba

150519
T Librae

0958.0	12.5	Ho
83.7	<13.0	Ba

150605
Y Librae

0958.0	11.2	Ho
83.7	11.9	Ba

151520
S Librae

J.D.	Est.	Obs.
242		
0958.0	11.0	Ho
62.8	11.0	E

151614
S Serpentis

0984.6	12.2	Ba

151731
S Cor. Bor.

0964.6	9.5	Ba
71.6	9.1	Ba
73.6	9.8	O
74.6	9.9	O
74.7	9.6	M
83.7	10.0	Ba
84.6	10.0	O
93.6	10.0	O

152714
RU Librae

0958.0	10.7	Ho
83.7	8.7	Ba

153378
S Urs. Min.

0960	9.0	Mu
63	8.9	Mu
64.6	8.7	Ba
71.6	8.5	Ba
72.7	9.2	M
73.6	8.9	Pi
73.6	9.8	Bu
74	8.7	Mu
76	8.6	Mu
81	8.5	Mu
83.7	8.4	Ba

154428
R Cor. Bor.

0956.6	6.1	Nt
56.6	6.0	O
56.9	6.0	E
58.7	6.0	Bu
59.6	6.0	Nt
61.6	5.9	Nt
62.8	6.1	E
63.6	5.8	Ba
64.6	5.9	Nt
64.6	5.8	Ba
66.6	5.8	Ba
71.6	5.5	Ba
73.6	6.0	O
74.5	5.9	Nt
74.6	6.0	O
74.7	6.0	M
74.6	5.7	Ba
74	6.2	Mu
75	6.1	Mu
75.7	6.2	R
76.7	5.9	R

R Cor. Bor.

J.D.	Est.	Obs.
242		
76	6.0	Mu
77.6	6.0	E
77	6.1	Mu
78	6.0	Mu
79.7	6.0	M
79	6.1	Mu
80.7	6.0	E
81	5.7	Mu
82	5.9	Mu
82.6	5.9	Ma
83	6.0	Mu
83.6	6.4	Ma
83.7	6.0	Ba
84.6	6.0	O
84.6	5.9	Nt
84	6.0	Mu
84.6	6.0	Ba
90.7	6.0	Mr
90.7	6.0	Wh
93.6	6.0	O

154536
X Cor. Bor.

0974.6	11.6	Ba
83.7	11.7	Ba

154539
V Cor. Bor.

0971.6	8.3	Ba
79.7	9.7	M
83.7	8.6	Ba

154615
R Serpentis

0962.8	7.5	E
64.6	7.5	Ba
71.6	7.5	Ba
74.6	7.4	O
80.9	7.6	E
83.7	7.3	Ba
84.6	7.4	O
93.6	8.0	O

155229
Z Cor. Bor.

0984.6	12.5	Ba

155847
X Herculis

0959	6.9	Nt
61	6.9	Nt
64	6.9	Nt
74	6.9	Nt
84	6.9	Nt

160118
R Herculis

0971.6	9.8	Ba
83.7	10.7	Pi
83.7	10.7	Ba

160210
U Serpentis

J.D.	Est.	Obs.
242		
0962.8	9.3	E
64.6	9.5	Ba
71.6	10.0	Ba
83.7	10.3	Ba

160625
RU Herculis

0964.6	11.1	Ba
83.7	11.0	Pi
83.7	10.8	Ba

161138
W Cor. Bor.

0962.8	12.5	E
74.6	<11.2	O
83.7	13.0	Ba

162112
V Ophiuchi

0958.0	7.4	Ho
79.0	7.4	Ho
84.7	8.0	Ba

162119
U Herculis

0962.8	11.2	E
79.7	9.9	M
83.7	9.7	Pi
83.7	9.3	Ba

162807
SS Herculis

0983.7	12.0	Ba

162816
S Ophiuchi

0960.0	10.2	Ho

163137
W Herculis

0964.6	8.6	Ba
83.7	8.9	Pi
83.7	9.2	Ba
93.6	9.2	O

163172
R Urs. Min.

0972.7	9.2	M
73.6	9.4	Pi
73.6	9.4	Bu
84.7	9.1	Ba

163266
R Draconis

0959.6	7.2	Cr
60.6	7.2	Cr
61.7	7.2	R
64.6	7.3	Ba
71.6	7.7	Cr
72.7	7.5	M
73.6	7.2	O
76.7	7.4	R

VARIABLE STAR OBSERVATIONS Apr.-May, 1915—Continued.

Star	J.D. 242	Est.	Obs.
R Draconis	0979.7	7.7	M
	81.6	8.0	Cr
	82.6	7.6	Ma
	83.7	7.7	Ba
	84.6	7.7	O
	93.6	7.7	O
164055 S Draconis	0979.7	8.7	M
164319 RR Ophiuchi	0958.0	10.2	Ho
	79.0	11.6	Ho
164715 S Herculis	0962.8	7.2	E
	79.7	8.0	M
	83.7	7.3	Pi
	84.7	7.0	Ba
165030 RR Scorpii	0960.0	9.6	Ho
	79.0	10.4	Ho
165631 RV Herculis	0962.8	12.5	E
	79.7	11.6	M
	83.7	<12.2	Pi
	84.7	<13.4	Ba
170215 R Ophiuchi	0962.8	6.9	E
	84.7	6.9	Ba
171401 Z Ophiuchi	0962.8	9.0	E
	84.7	9.1	Ba
171723 RS Herculis	0983.7	8.5	Pi
	84.7	8.2	Ba
172809 RU Ophiuchi	0962.8	11.0	E
	80.8	9.5	E
	84.6	9.4	Ba
175458 T Draconis	0984.5	10.8	Ba
175519 RY Herculis	0962.8	13.5	E
	80.8	<13.4	E
	83.7	<11.8	Pi
	84.7	<13.2	Ba
180531 T Herculis	0962.8	11.5	E
	79.7	<11.0	M
	83.7	<12.0	Pi
181136 W Lyrae	0958.9	9.6	E
	62.8	10.0	E
	84.7	11.2	Ba
183308 X Ophiuchi	0962.8	8.9	E
	84.7	8.7	Ba
184243 RW Lyrae	0956.9	12.9	E
184205 R Scuti	0956.9	6.0	E
	60.0	5.8	Ho
	62.9	5.8	E
	79.0	5.5	Ho
	80.8	5.2	E
	84.8	5.8	Bu
	84.7	5.2	Ba
	92.8	5.2	Pi
190108 R Aquilae	0980.8	11.2	E
190529 V Lyrae	0984.7	10.1	Ba
190926 X Lyrae	0958.9	9.2	E
	84.7	9.0	Ba
191019 R Sagittarii	0979.0	<11.5	Ho
	80.9	12.2	E
191637 U Lyrae	0962.9	11.2	E
	84.7	11.0	Ba
192928 TY Cygni	0880.9	9.4	E
	84.7	9.4	Ba
193311 RT Aquilae	0984.7	9.1	Ba
193449 R Cygni	0958.9	10.0	E
	62.9	9.6	E
	80.9	9.3	E
	84.7	9.2	Ba
193509 RV Aquilae	0962.9	9.1	E
	80.9	9.1	E
	84.7	9.4	Ba
193732 TT Cygni	0958.9	8.2	E
	80.8	7.8	E
	84.7	7.5	Ba
194048 RT Cygni	0958.9	8.8	E
	62.9	8.1	E
	80.9	7.7	E
	83.8	7.5	Pi
	84.7	7.5	Ba
194348 TU Cygni	0958.9	<12.4	E
	62.9	<12.4	E
	80.9	<12.1	E
	83.8	<11.7	Pi
	84.7	<12.5	Ba
194604 X Aquilae	0962.9	11.7	E
	84.7	9.8	Ba
194632 χ Cygni	0956.9	8.9	E
	80.8	10.3	E
	84.7	10.0	Ba
200212 SY Aquilae	0984.7	10.6	Ba
200357 S Cygni	0962.9	<11.4	E
200647 SV Cygni	0962.9	9.0	E
	84.7	8.7	Ba
200715a S Aquilae	0984.8	9.5	Ba
200915b RW Aquilae	0984.8	9.1	Ba
200812 RU Aquilae	0983.8	<12.5	Ba
200916 R Sagittae	0984.8	9.0	Ba
200938 RS Cygni	0983.8	7.8	Pi
	84.7	7.2	Ba
201008 R Delphini	0983.8	9.3	Pi
201130 SX Cygni	0962.9	<12.6	E
201647 U Cygni	0962.9	8.0	E
	83.8	8.4	Pi
	84.7	7.8	Ba
202539 RW Cygni	0962.9	8.6	E
	84.7	7.9	Ba
202817 Z Delphini	0956.9	11.8	E
	83.8	10.9	Pi
	83.8	11.0	Ba
202954 ST Cygni	0962.9	<11.7	E
202946 SZ Cygni	0958.9	9.4	E
	84.7	9.6	Ba
203226 V Vulpeculae	0983.8	9.3	Ba
203611 Y Delphini	0983.8	<12.5	Ba
204318 V Delphini	0983.8	<12.5	Ba
205017 X Delphini	0983.8	10.5	Ba
205923 R Vulpeculae	0956.9	10.3	E
210129 TW Cygni	0983.8	12.7	Ba
210868 T Cephei	0984	10.4	Nt
213843 SS Cygni	0456.9	8.2	E
	58.9	8.4	E
	62.8	9.9	E
	62.9	10.0	E
	80.8	11.8	E
	83.7	11.6	Ba
	83.8	11.7	Pi
	90.7	11.3	Pi
	90.7	11.0	C
	91.8	9.8	Pi
	92.7	9.6	Pi
	92.9	10.0	M
214024 RR Pegasi	0983.8	10.1	Ba
220613 Y Pegasi	0980.9	<12.0	E
220714 RS Pegasi	0980.9	12.1	E

No. of observations 711; No. of stars observed 175; No. of observers 17.

The following list of calculated dates of maxima is cited from the "Companion to the Observatory."

June 12	070310	R Can. Min.	June 28	123160	T Urs. Maj.
14	200938	RS Herculis	29	180531	T Herculis
22	142539	V Bootis			

An event of great interest and pleasure to all who participated, (which, owing to lack of space can only be alluded to here), was the meeting of a fortunate group of our members at the home of Mr. D. B. Pickering, in East Orange, N. J., on the evening of May 6th on the occasion of the dedication of Mr. Pickering's splendidly equipped observatory which now crowns the roof-tree of his home. Ten members of the Association were present, and the guests of honor were Mr. Leon Campbell of the Harvard College Observatory staff, than whom no one has done more to promote the welfare of our organization, and Mr. Leon Barritt, the genial editor of the famous "Evening Sky Map" which is doing so much to stimulate interest in Astronomy.

Observations of sun-spots, Venus, Mercury, and Variable stars were made with Mr. Pickering's excellent 3½" equatorial. Following a bountiful repast, a feature of which was the souvenir presented by Mr. Pickering to his guests, a print of his observatory accompanying a clever and facetious description of the "House that "Pi" built", we had the pleasure of listening to an able paper on the subject of Variables by Mr. Campbell, and later enjoyed a large number of superior lantern slide views of the light curves of Variables, and scenes in the vicinity of Arequipa, Peru, which Mr Campbell described in detail.

The occasion was a red letter one in the history of the Association, and the cordial reception, the charm and hospitality of the Pickering home will live long in the memory of all who were fortunate enough to be present.

The following members contributed to this report:—Messrs. Bancroft, Bouton, Burbeck, Crane, Eaton, Hoge, Mach, McAteer, Miner, Mundt, Nolte, Olcott, Pickering, Richter, Vrooman, Whitehorn, Miss Young.

The Hagen traced chart of 115919 R Comae is defective. Will observers using this chart please return their print to the secretary when a correct chart will be sent them.

William Tyler Olcott,
Corresponding Sec'y.

Norwich, Conn.
May. 10, 1916.

COMMUNICATIONS.

A Peculiar Aurora.—A brilliant and very peculiar aurora was visible at Pittsburgh on Friday, April 28. Its presence was noted soon after dark. I first saw it at 10 o'clock. It then consisted of a beam of light exactly resembling a search-light extending vertically upward from near the horizon at a point about twenty degrees north of west, and three or four degrees south of Venus. The length was approximately thirty degrees and the width increased slowly to about three degrees at the top. From the thirty degree elevation it extended feebly to the zenith, or possibly a little beyond, the southern boundary being continuous with a strong beam, while to the north it widened suddenly. This part for a time consisted of a number of short vertical shafts of light, rather bright, and separated by feebler luminosity. The whole width of this part was perhaps thirty degrees. A half hour later it had practically all disappeared. At midnight a straight shaft of light extended from north-west to south-east at least one hundred and fifty degrees long, disappearing at either end in the pall of smoke which overhung the city. It was inclined about fifteen degrees to the east and west line. Arcturus, which was at that time near the meridian, was just on the northern edge of the beam which was nowhere more than three degrees wide, and varied little from end to end. It wavered somewhat, and at one time was considerably disturbed in the neighborhood of the meridian.

This beam lasted about half an hour, gradually fading away. There was no further manifestation of auroral activity during the night. Neither this beam nor the earlier one showed any color.

FRANK C. JORDAN.

Allegheny Observatory,
Pittsburgh, Pa. April 29, 1916.

An Unusual Aurora.—I wish to tell you of a beautiful phenomenon which occurred April 27. About 10:21 I noticed a small patch of light in the east. I turned away and less than a minute later I looked back, when to my surprise this seemingly inconspicuous light had hurled itself across the sky in a beautiful path about 5 degrees in width. It lingered until about 10:51 then faded away.

PHILIP TRUDELLE.

Chippewa Falls, Wis.

The Aurorae of April 27th and 28th.—While I was out observing meteors on the 27th of April, aurorae began to show up about 8:30. They were faint, nebulous and a pale green. They slowly mounted toward the zenith and grew brighter as they did so. About 10:20 I looked over in the east and saw a pale yellow streamer of light that looked like a great comet tail. It stayed like this for five minutes then it widened in the center and got narrow on the ends. It extended from the horizon up into the sky along the ecliptic about 60° and was about 4° wide. At 10:25 it began to grow longer at 10:26 it had completely stretched across the sky from east to west along the ecliptic. It passed above Virgo, above Leo and between Castor and Pollux. At 10:30 it shifted 10° south so that it passed directly along the ecliptic. About 11:30 it had completely faded away. When it started, sharp flashes of purple light came from the northern horizon and swept upward to the zenith. They followed one another about 30 per minute. At 12 o'clock bands of light came from the northern horizon that were about 3° wide, stretching from east to west. They mounted zenithward and would suddenly disappear when they reached Polaris.

On the 28th the band along the ecliptic appeared again and went through similar changes. It disappeared about 9:15. The aurorae became more brilliant than they were on the 27th of April.

JOHN KOEP.

Chippewa Falls, Wis.

A Striking Aurora.—At about 10:40 p. m. April 27 a bright band of white light was seen stretching across the whole sky from a point a little north of west to a point a little south of east. Passing between Castor and Pollux, which were near the western horizon, it crossed the meridian south of the zenith and passed over Arcturus, touching the eastern horizon at a point about 15° south of the western end of the arc. The arc moved slowly southward the western end appearing to act as a pivot. At the same time the band, which at first was slightly wider than a rainbow, became wider and more diffuse. This occurred more rapidly in the eastern than in the western part. In about half an hour the light had nearly died out. About a quarter to twelve another band similar to the first but much shorter was seen. It extended from a point east of Arcturus nearly to the eastern horizon. This one in fading out formed a second very faint streak which was visible for just a moment parallel to the main one.

The next night two more bands were seen, both stretching across the whole sky. The first was noticed at about five minutes past nine. At this time it was more diffuse than those of the previous night were when first observed, and it was brighter in the eastern than in the western part. It disappeared in about twenty minutes. Later in the evening another still fainter band was seen.

Ordinary forms of aurora borealis were also observed on both evenings.

FRANZ M. EXNER.

Northfield, Minn.

GENERAL NOTES.

The next issue of POPULAR ASTRONOMY, the August-September number, will appear about August 1.

Professor George E. Hale gave an account of the progress of his study of solar phenomena, at the meeting of the American Academy of Sciences in Boston on May 10.

Professor W. H. Pickering, who has been making extensive observations on Mars for the past few years in Jamaica, is at present at the Harvard College Observatory.

Mr. Bernhard H. Dawson, who has been studying at the University of Michigan, will leave some time in July to resume his position as astronomer in the Observatory of LaPlata.

Professor H. C. Wilson, who is spending this semester in Harvard College Observatory as Visiting Lecturer in Harvard University, lectured before the students in astronomy at Mt. Holyoke on Saturday May 13. The subject of his lecture was "A Trip to the Moon."

Dr. William Frederick King, Director of the Dominion Observatory at Ottawa, and Astronomer Chief for Canada, died at his home on Sunday April 23. An account of the life and work of Dr. King is given by Professor C. A. Chant, as the first article in this issue.

Professor Ralph H. Curtiss has been granted a leave of absence by the Board of Regents of the University of Michigan for two or three years. Professor Curtiss will go to Argentina to inaugurate stellar spectroscopic work at the Observatory of the University of LaPlata. Leave of absence was also granted to Mr. H. J. Colliau, who will accompany Professor Curtiss and assist in installing the spectrograph and other apparatus.

The Public Observatory at Sound Beach, Conn., is in need of an additional telescope. The director Mr. Edward F. Bigelow, requests us to announce that he should like either a gift of a telescope, a three or four inch mounted on a tripod, or money to obtain one.

The 72-inch Reflecting Telescope, designed and constructed for the Dominion Astronomical Observatory, Victoria, Canada, by the Warner and Swasey Company, has been completed. An exhibition of this instrument was held in the factory of the makers at 5701 Carnegie Avenue, Cleveland, on May 26, 1916. Invittaions to be present at the exhibition were sent to astronomers and others throughout the country who were interested.

Telescope Presented by a College Class.—The class of 1916 of Millsaps College became so much interested in the photographing of the solar eclipse, described elsewhere in this number, that the class has purchased the telescope with which the photographs were made and has presented it to the college. Professor Harrell states that he has secured good results upon nebulae with it.

The Heavens is the name of a monthly publication of the Astronomical Society of Los Angeles. It was begun in April, and two issues have reached us. It is to be a "Monthly Record of the Stars, Planets and Astronomical Events." It is designed to answer the numerous untechnical questions which arise. The subscription price is one dollar a year.

Reader's Guide Supplement.—The readers of this journal will be pleased to learn that this is one of those journals whose contents are indexed in the *Reader's Guide Supplement* published by the H. W. Wilson Company, White Plains, N. Y., and to be found in many of the public libraries. The *Supplement* is issued in January, March, May, September and November, each issue including all the preceding ones for the year, beginning with the March issue. The annual subscription price to this *Supplement* is determined by a sliding scale depending upon the number of magazines which are subscribed for by a given library and indexed in the *Supplement*. It doubtless will be found of great use in locating papers relating to a given topic.

The Allegheny Observatory.—It was with much regret that I read the last paragraph on page 334 of the May issue of POPULAR ASTRONOMY. Mr. Bigelow visited our observatory not long ago and we gave him every facility to study the same and to see the wonderful work that is being done here, and then to comment as he has done in his article on "The greatest need of astronomy" is something I cannot understand, although he says he does it in no spirit of adverse criticism. His general comment on the observatories of the United States as "a failure and a farce" is certainly discreditable to Mr. Bigelow, and particularly when he bases it upon the fact that the observatories are not contributing to the instruction of the public.

I agree with him that it would be a splendid thing to have a free observatory in every town and two or three in every city of the United States, for I saw the time myself when, as a workman in the rolling mill, I would have given almost anything I owned to have the pleasure of studying the heavens in a telescope, and I determined that if ever I had an opportunity or could make one, I would use my best efforts to have an observatory open to the people, and we have now put up this beautiful observatory with one of its departments forever free to the people in which we have placed the 13-inch telescope nicely remounted, which is as efficient as any new telescope of 12-inch aperture, and we also have a beautiful lecture room connected with it.

We are also making preparations to put up another observatory, to be forever free to the people, which is to be placed in Schenley Park in the East End, so that residents of the districts far away from us can be accomodated.

Mr. Bigelow says:—"But what amuses me is that the people of Pittsburgh and Allegheny think that they have an observatory. They have nothing of the kind. The technical workers have an observatory. I sincerely hope they will keep it and make good use of it, but what I am pleading for is that those cities and every other city in the United States will establish an observatory that shall be for the people and not exclusively for the few who are skilled in technical research." I confess I cannot understand this, from the fact that while the Allegheny Observatory, with the work of its director and its splendid corps of assistants, takes very high rank in the domain of astrophysical and astronomical research, its free department which has been open for six years, during every month in the year that was at all favorable for observation, has afforded over nineteen thousand people an opportunity of seeing objects in the telescope, with a descriptive lecture by members of the staff or a member of the local astronomical society. When the nights are unfavorable, the visitors are taken into the lecture room of the observatory, designed and fitted up purposely for the public, where lectures are given, illustrated with lantern slides, and as we have command of many hundred slides, they can always spend a pleasant and profitable evening, although our good friend says, "It has not lifted in the slightest degree the shades of ignorance that obscure the heavens."

Mr. Bigelow also speaks of us using "the small telescope" made by Alvan Clark, "the same that Langley used more than half a century ago." Let me say that even this telescope of 13-inch aperture is too large for general use, and were I to advise as to a telescope for a public observatory, I would not think of having one over 10-inch aperture, from the fact that you can use a 10-inch telescope for visual purposes under general atmospheric conditions in which observations have to be made, at least ten times where you could use a 30-inch once. It is a pity that Mr. Bigelow does not know this, as he criticizes our people, saying that our 30-inch "has never been and never will be looked through by even one citizen of Pittsburgh or Allegheny, because it is not adapted to visual observations; it is a photographic lens." This is a false statement as, while the great lens is corrected for photographic purposes, it has a visual correcter and only a few nights ago a visiting group had some beautiful observations of the planets in this telescope.

We also have an astronomical society in Pittsburg, composed almost entirely of those who from time to time have the use of the telescope. This society meets in the lecture hall, and the staff of the observatory give occasional talks of value to those who attend the meetings. Last week the address was on the Herschels, by Miss Bender of the observatory staff.

Reading Mr. Bigelow's article called "An open letter to Mr. Andrew Carnegie" in the Guide to Nature, I can tell him why it was possible to raise such a large sum of money for the Allegheny Observatory and equipment. It was because of the splendid record that has been made in the institution of the very kind of work which he condemns, much of which is known and understood by the laymen interested in astronomical studies.

In closing this already too lengthy note, let me say there are many observatories, east and west, some, like the splendid institution at Oakland, California, presided over by that enthusiastic astronomer Professor Charles Burckhalter are always open to the rank and file of the lovers of astronomy. Then the Lick Observatory, also in the far west; the Flower Observatory in the east—yes, even the United States Naval Observatory is open to visitors. I could name others that are ever ready to lend a helping hand to the lovers of the stars, and let me say astronomers all over this land have been giving lectures for the past twenty-five years, nine tenths of them free to the people. Pardon me if I put in a little of the ego by saying I have given over four hundred lectures in the last quarter of a century on the beauties of the heavens, and propose to keep it up until my hearers get tired of me or these old vocal organs fail to respond to my wish and will.

John A. Brashear.

Pittsburgh, Pa.
May 13, 1916.

Actual Time of Signals from the U.S. Naval Observatory, April, 1916.

Day	Time of signals Noon			Error	Time of signals 10:00 p.m.			Error	
	h	m	s		h	m	s		
1	12	0	0.03	+.03	10	0	0.05	+.05	
2	12	0	0.07	+.07	10	0	0.10	+.10	Sunday
3	12	0	0.09	+.09	10	0	0.10	+.10	
4	12	0	0.11	+.11	10	0	0.13	+.13	
5	12	0	0.13	+.13	10	0	0.15	+.15	
6	12	0	0.11	+.11	10	0	0.12	+.12	
7	12	0	0.02	+.02	10	0	0.01	+.01	
8	12	0	0.00	.00	10	0	0.03	+.03	
9	12	0	0.04	+.04	10	0	0.03	+.03	Sunday
10	11	59	59.99	—.01	9	59	59.97	—.03	
11	11	59	59.97	—.03	9	59	59.98	—.02	
12	11	59	59.96	—.04	9	59	59.96	—.04	
13	12	0	0.04	+.04	10	0	0.01	+.01	
14	12	0	0.01	+.01	10	0	0.02	+.02	
15	12	0	0.03	+.03	10	0	0.02	+.02	
16	12	0	0.03	+.03	10	0	0.01	+.01	Sunday
17	12	0	0.01	+.01	10	0	0.03	+.03	
18	12	0	0.02	+.02	10	0	0.01	+.01	
19	12	0	0.00	.00	10	0	0.02	+.02	
20	12	0	0.03	+.03	10	0	0.00	.00	
21	12	0	0.02	+.02	10	0	0.02	+.02	
22	12	0	0.03	+.03	10	0	0.02	+.02	
23	12	0	0.04	+.04	10	0	0.02	+.02	Sunday
24	11	59	59.99	—.01	9	59	59.98	—.02	
25	11	59	59.98	—.02	9	59	59.98	—.02	
26	11	59	59.98	—.02	9	59	59.95	—.05	
27	11	59	59.94	—.06	9	59	59.97	—.03	
28	11	59	59.95	—.05	9	59	59.94	—.06	
29	11	59	59.99	—.01	10	0	0.01	+.01	
30	12	0	0.01	+.01	10	0	0.00	.00	Sunday

Maximum error: Apr. 4, +0.15 sec.

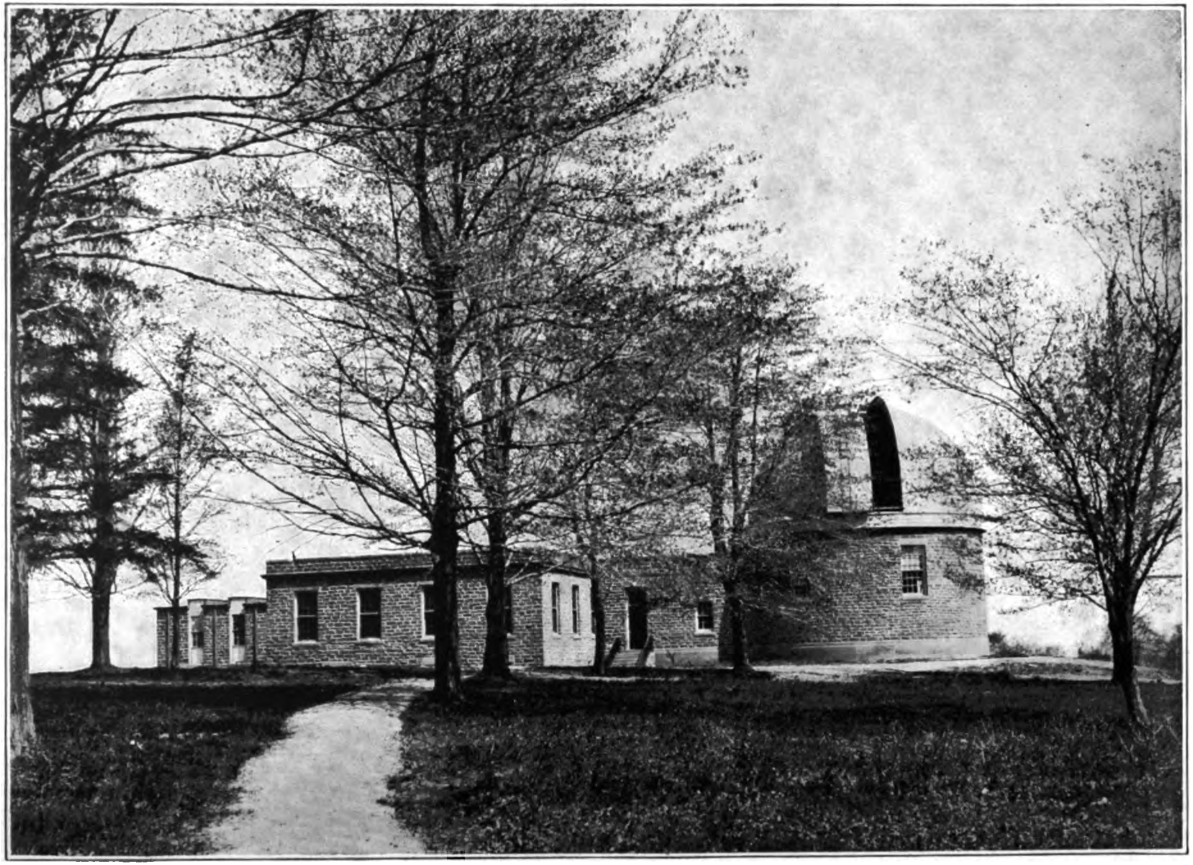
Constant to be added to above errors to give error of radio signals from

Arlington +0.02 sec.
Key West +0.27

J. A. Hoogewerff,
Captain U. S. Navy
Superintendent.

U. S. Naval Observatory,
Washington, D. C.
May 5, 1916.

PLATE XXIII



THE VANVLECK OBSERVATORY FROM THE SOUTH.
WESLEYAN UNIVERSITY, MIDDLETOWN, CONN.

Popular Astronomy.

Vol. XXIV, No. 7. AUGUST-SEPTEMBER, 1916. Whole No. 237

THE FUNCTION OF THE VAN VLECK OBSERVATORY.*

FREDERICK SLOCUM.

There is evidently much doubt in the minds of some people as to just what an observatory is, and what it is for.

A teamster came up here some time ago with a load of window frames for the new dormitory. When told that he had come to the wrong place, that this was the observatory not the dormitory, he paused a moment and then asked, "Well, what's the difference anyway?"

An expressman one day enquired about the significance of the building, and when informed that it was for the study of the heavens, remarked that he hoped it would do some good.

A neighbor reports a conversation with her maid, who asked about "that queer building up on the hill." When she was told that it was an observatory and contained telescopes through which the students looked at the sun, moon, and stars, she replied: "They'd much better look into their own hearts. That's what I think."

The building has been likened to a fort, and the dome to a bee-hive, and even to a sore thumb. The most encouraging comment on the exterior appearance of the structure is one by a member of the Wesleyan Faculty, which I take the liberty of quoting.

"Little bits of plaster,
Little blocks of stone,
Make a handsome building,
When the ivy's grown."

The observatory does not, as one of the papers stated last Sunday, combine all of the best features of the best observatories in Europe and America, but it does contain as many desirable features as our fund would allow.

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* Read at the dedication of the Van Vleck Observatory of Wesleyan University, June 16, 1916.

The function of the Van Vleck Observatory of Wesleyan University, it seems to me, is twofold; instruction and research. In some universities there is a sharp line of demarcation between these two, and such a division may be necessary in the case of very large classes, but, to my mind, research is one form of instruction and instruction without research is apt to become dry. The two should go hand in hand, or at least, if possible, should be carried on under the same roof.

Someone has likened a course in astronomy to a trip abroad. The pleasure of travel and its broadening effect are of course recognized, and there is a similar widening of the vision from a personally conducted tour through the heavens with a telescope. From this point of view alone courses in astronomy would be justified, but there are other characteristics equally worth considering.

The courses now offered here at Wesleyan are of four quite different types. First there is a general descriptive course, chiefly informational in character. A standard elementary textbook is used, and just enough laboratory work or rather observatory work is introduced to make the text perfectly clear. Second, a course in the history of astronomy. This might be classed as purely cultural. There is no adequate text on this subject, so the course is conducted by lectures illustrated with the telescope and by photographs and lantern slides.

We begin with the birth of astronomy among the shepherds on the Chaldean hills some 3000 years B. C., trace its development in Greece, noting especially the part it played in the philosophy of Pythagoras, Plato, and Aristotle, then follow its history in Alexandria, Babylon, and Spain. Passing over the dark ages, we dwell a little longer upon the great revival in Europe, in which five great men stand out so prominently: Copernicus the Pole, Tycho Brahe the Dane, Kepler the German, Galileo the Italian, and Sir Isaac Newton the Englishman. At the hands of these five men the science of astronomy was completely revolutionized and started upon a new line of development, which has continued, ever becoming more extensive and intensive, culminating in the wonderful discoveries being made with the various forms of spectroscopes in recent times. Only the general characteristics and most prominent features of this development are discussed. The aim is to give the student a general idea of what is included in the science of astronomy, how the science has developed, and its relation to other branches of learning.

The third course is one in practical astronomy. The students from the very beginning use instruments, make observations, and reduce them. They deal with such problems as the determination of accurate time as used for railroad and other commercial purposes, and the determination of latitude, longitude, and azimuth, as used in the higher surveying on land, and in navigation at sea.

The remaining courses may be included in one class. They are all laboratory courses and deal with the more difficult problems of theoretical and practical astronomy. They may be grouped together because of one common characteristic. These classes will always be small and the students will, to some extent, take part in the routine research work of the observatory, thus getting some insight into the methods of modern astronomical investigation.

When the first plans of this building were being drawn, it was recognized that its chief function was to be the teaching of astronomy, and the question arose as to whether it would be better to equip it with a number of small instruments, or with a single telescope as large as the fund would allow. With two or three small telescopes, more of the students in the elementary courses would be able to make some simple observations. With the single larger instrument, the phenomena of

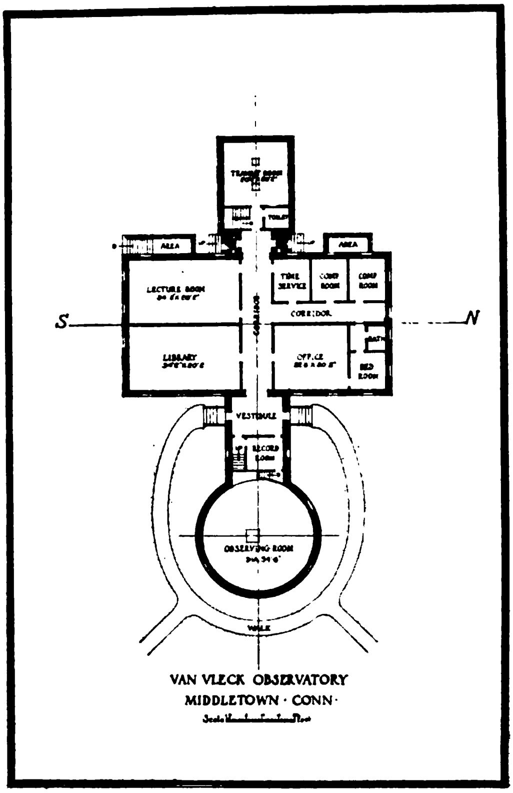


FIGURE 1.
PLAN OF THE MAIN FLOOR OF THE VAN VLECK OBSERVATORY.

descriptive astronomy could be better illustrated, research work of some value could be done by the director, and advanced students, and, it was thought, that not only the advanced students, but those in the elementary classes as well would derive greater inspiration from this higher grade of work, and, as you know, the second plan was finally adopted.

In discussing this phase of the function of the observatory the problem of the entertainment of visitors should perhaps be considered. Scarcely a day passes without a request from someone to be shown through the building. On Washington's Birthday about 200 people were thus entertained. A number have asked permission to visit the observatory at night and to look through the telescope. This has been granted whenever it could be done without conflicting with the regular night classes.

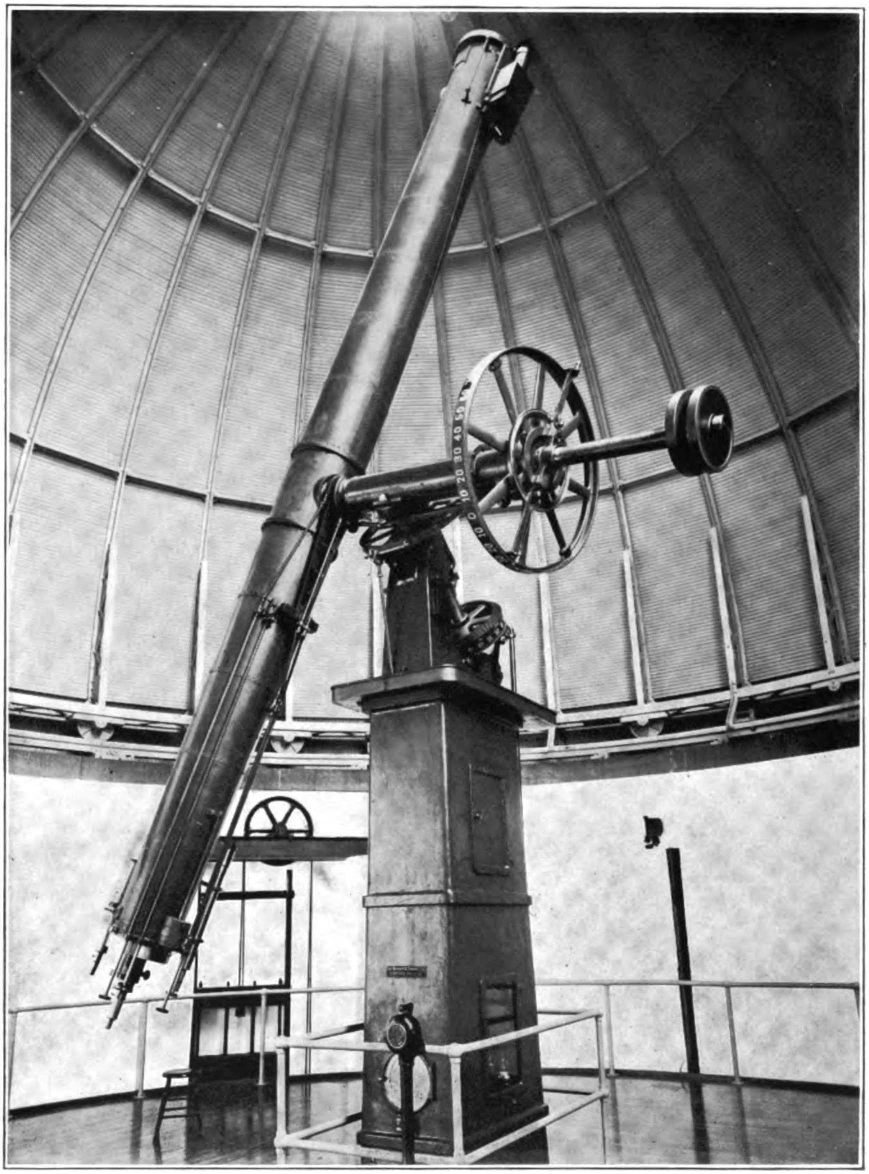
In some cases the visitors have come apparently out of mere curiosity rather than through any interest in the subject of astronomy. However, such curiosity is, no doubt, perfectly legitimate, and I believe that the observatory ought to make some provision to satisfy it. It may be possible next year to set apart certain days and perhaps one or two evenings per month for visitors.

As to the research program of the observatory, from some of the replies to the invitations to the dedication, I have been able to learn, to some extent, what is expected. For example one alumnus writes, "We expect great results from you in the future. If you do not discover a tenth moon of Jupiter, we fully expect you to do some other work which the alumni will recognize and appreciate."

Now I have not the slightest idea of hunting for a tenth moon of Jupiter, and if I ever should find one, it would be purely by accident. In this connection I am reminded of a story which appears in the biography of Galileo. In the year 1604, while Galileo was a professor at Padua, a new star blazed out in the constellation of the Serpent and attracted great attention, chiefly, perhaps, because it apparently contradicted the teachings of Aristotle and the church, that the heavens were unchangeable, perfect, subject neither to growth nor to decay. Galileo was invited to give a course of three lectures on the new star. At the first lecture there were over 1000 people, and the second lecture had to be given in the open air because there was no hall in the city large enough to hold the audience.

In opening his first lecture he took occasion to rebuke his hearers for thronging to learn about that transient phenomenon, while showing absolutely no interest in the far more wonderful truths about the permanent stars.

PLATE XXIV



THE EIGHTEEN AND A HALF INCH TELESCOPE OF THE VANVLECK OBSERVATORY. RISING FLOOR ABOUT THREE FEET ABOVE THE LOWEST POSITION.

POPULAR ASTRONOMY, No. 237.

Occasionally, to be sure, the sensational serves a good purpose by attracting the attention of some genius whose interest in the science remains after the ephemeral novelty has passed. For example it was the blazing out of a new star that led Hipparchus to make the first star catalogue. And again it was the appearance of a new star which started Tycho Brahe on his astronomical career, but his great contribution to astronomy is the long series of careful and laborious observations of the motions of the planets.

In planning the program of research for this observatory I have adopted the following precepts:

First, the sensational or transient phenomena should be ignored, or, as least, subordinated to the problems which will yield positive results of permanent value.

Second, the problems to be studied should be such as can be satisfactorily investigated in the relatively bad climate of New England. An eminent astronomer has recently told us that it is absolutely useless to try to see any exceedingly faint and delicate markings like the canals on Mars in New England. The atmosphere is rarely, if ever, sufficiently transparent or steady enough.

Third, the telescopic equipment which could be provided from the available fund must be considered.

And finally, the experience and training of the astronomer must be taken into account.

With these conditions and limitations in mind I have searched the frontier of astronomy for the most suitable problem.

In every age there have been certain great problems in astronomy which have overshadowed all the rest.

For example among primitive people it was the question of the shape of the earth, as to whether it was flat or spherical. Later it was the rising and setting of the sun, moon, and stars. How were they carried across the sky? Were they borne on crystal spheres, or did they just fly over like a stone that is thrown? And how did they get back from the west to the east every day? Were they carried around behind the northern mountains, or did they pass through some underground channel? And were the lights of the stars extinguished when they went down into the western sea, and relighted in the east twelve hours later?

Again it was the motions of the planets that puzzled the astronomers; rising and setting like the stars, but unlike the stars, zigzagging back and forth and describing loops and curves. The Ptolemaic System of epicycles—wheels upon wheels—finally solved this problem to the satisfaction of most astronomers for about 1500 years, then it was completely overthrown.

The next great problem was the question of the influence of the heavenly bodies upon human destiny, and during the fourteenth and fifteenth centuries the astrologer was a dominant factor in every court in Europe. Today, however, astrology is, of course, wholly discredited.

Once more the question of planetary motion came up, and was almost completely solved. The size and shape of each orbit around the sun was correctly determined, and the fact that the motions of the planets are due to the attraction of gravitation was proved by Sir Isaac Newton. All that remained was to explain what gravitation really is. This problem is, of course, still unsolved.

During most of the eighteenth century astronomy was concerned chiefly in making catalogues of the positions of the stars and planets; very important but somewhat monotonous.

Towards the end of the century, however, a new problem arose, that of locating the stars in space, and of answering such questions as these: Is the number of stars infinite or finite? Do the stars form a system? Are they confined within a finite limit, or do they extend through all space? Are the stars really fixed, or are they moving, but so far away that their motions are imperceptible? Is our sun fixed or in motion? Are the star clusters really separate sidereal systems, far away? What is the Milky Way? Such questions as these characterized the great problem of the eighteenth century.

Again the pendulum of interest swung back to the planets. With the discovery of Uranus, the Asteroids and Neptune, attempts were made to explain the origin and development of the solar system. The Nebular Hypothesis and other theories were the result.

During the latter part of the last century the discovery of the principles of spectrum analysis and the introduction of photography into astronomy opened up the new field of astrophysics, which deals especially with the study of the chemical composition of the stars.

These are just a few of the great problems of the astronomy of the past. Now the greatest astronomical problem of the present time, it seems to me, is precisely that one of the eighteenth century which deals with the determination of the structure of the sidereal universe, but in our day it is being attacked in quite a different way. In fact, it is being attacked in a great variety of ways.

First of all it is, of course, necessary to determine the actual distances of the stars, but it has been found that closely connected with their distribution in space are many other characteristics, for example, the magnitudes or brightness of the stars, their motions, apparent or real, their spectral types or chemical composition, to a certain extent their physical natures, densities and masses, and their grouping into clusters; also the status of the nebulae and the interpretation of the Milky Way must be considered.

It may seem natural that the nearer stars should, on the average, be brighter than the more distant ones, and that the nearer stars should appear to move the faster, but it is not so evident why the so-called metallic stars should be nearer than the hydrogen or helium stars, nor is it so clear why there should apparently be a relation between the evolution of the stars and their distances from our sun.

This question of the interpretation of the structure of the stellar universe is so broad that, so far as I know, there is but one observatory in the world that is trying to attack it along all possible lines, and that is the Mt. Wilson Solar Observatory, of which our distinguished guest is the director.

With our modest equipment here at Wesleyan, it will be necessary to concentrate our attention chiefly upon one single line, and I have therefore selected as the main item on our research program the determination of the distances of the stars. This, it seems to me, is, all things considered, the kind of work which can be done most satisfactorily in our climate and with our equipment. The details of the proposed observations would not interest you. It is sufficient to say that the work will be done by photography and the plates will be measured on a machine which you will see later in the computing room.

The field for this line of work is practically unlimited, and one observatory cannot possibly cover it all. Last year the American Astronomical Society appointed a committee to promote the coöperation of as many observatories as possible in the determination of stellar distances. As a result of their labors, eight observatories have agreed to include this problem in their research program. The eight are the Greenwich Observatory, in England, and, in this country, the Mt. Wilson Solar Observatory, the Yerkes Observatory, and the Observatories at the University of Virginia, Swarthmore, Northwestern, Allegheny, and Wesleyan.

This particular investigation will probably not produce any sensations, but it is hoped that it will yield results of permanent value. Other subordinate problems will of course be investigated whenever it is possible to do so.

Now just a word in regard to the general methods of astronomical research. The popular idea is that, whenever the spirit moves him, the astronomer simply sits at his telescope and watches the heavens in the hope that he may see something new, but such is by no means the case. Strange as it may seem, the efficiency germ is gradually working its way into the observatories. The astronomers realize the value of their equipment and seek to make the best possible use of it. The big telescopes are never allowed to stand idle when the weather conditions are such that observations can be made. For example, in the case of the great 40-inch telescope of the Yerkes Observatory, every hour of the night, from about half an hour after sunset to half an hour before sunrise, is assigned to some member of the staff, and each one is supposed to be on duty during the hours assigned and to use the telescope for the definite problem on his program, whenever the sky is clear. During the daytime the instrument is used for observations on the sun.

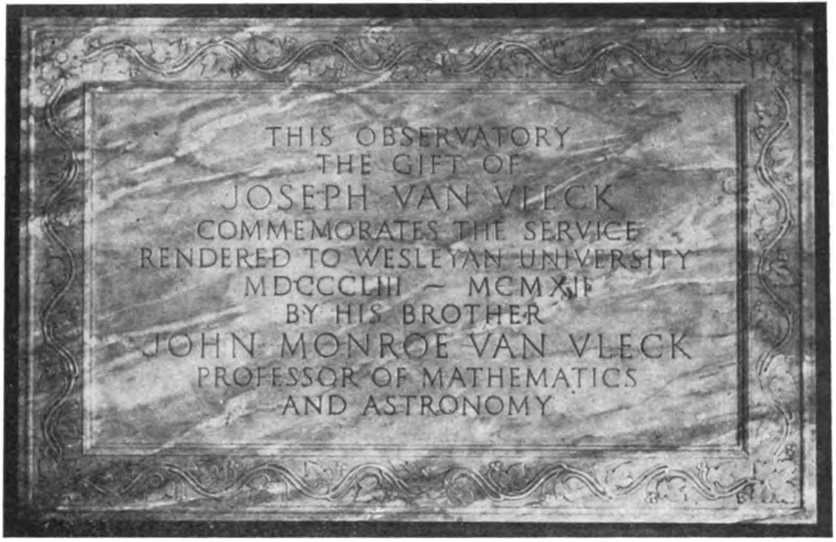
Again, while the telescope is in use, every precaution is taken to avoid waste of time. The work is nearly all done by photography, and two men are always in the dome. While one is exposing a plate the other is writing up the records and selecting the next region to be photographed. As soon as the time is up, one goes to the dark room to take out the exposed plate and put a fresh one in the plate holder, while the other is setting the telescope for the next exposure.

Similarly in measuring the plates and carrying out the reductions, the attempt is made to introduce the most efficient methods. Mechanical computing machines are used whenever possible, and all elementary routine work is turned over to computers and assistants.

This, of course, is an ideal scheme, but it takes men and money. Five men are required to keep the Yerkes telescopes working full time, and twice that number of assistants and computers should be provided for the reduction of their observations. At the Harvard Observatory there is a staff of about forty, including all assistants, and at the Mt. Wilson Observatory between fifty and sixty. These are two of the greatest research observatories in the world. How small these figures make our little plant look! However, it will grow, somewhat at least. In our plans of the building we have tried to provide for some expansion in the future, not so much along the line of instrumental equipment as in personnel. It is my ambition to see this telescope used every clear night, all night, and, to a certain extent, during the daytime. At present this is of course physically impossible, but I hope that some day we may be able to approach more nearly the goal of our ambition. One additional observer and a computer would easily treble our output.

Such then is our program: instruction combined with systematic research in connection with one or more definite problems. If I were to choose a motto for the observatory I think it would be "Concentration and Efficiency."

I sincerely regret that in planning this building I did not have the counsel and advice of two men, the memories of whom are uppermost in my mind today. I refer to Winslow Upton, late professor of astronomy in Brown University, and Professor John M. Van Vleck.



THIS OBSERVATORY
THE GIFT OF
JOSEPH VAN VLECK
COMMEMORATES THE SERVICE
RENDERED TO WESLEYAN UNIVERSITY
MDCCCLIII – MCMXII
BY HIS BROTHER
JOHN MONROE VAN VLECK
PROFESSOR OF MATHEMATICS
AND ASTRONOMY

FIGURE 2.

TABLET IN THE MAIN CORRIDOR OF THE VAN VLECK OBSERVATORY.
IT IS OF SIENNA MARBLE, 33x52 INCHES.

It was Professor Upton who inspired me to take up astronomy as a profession, and during the fifteen years in which I was associated with him, I learned to know and honor him as a great and noble teacher and a sincere and loyal friend. To him I owe more than I can express.

Though never intimately associated with Professor Van Vleck, I nevertheless had the good fortune to know him slightly, having met him occasionally at the astronomical meetings, but since coming to Wesleyan, I have learned to appreciate much more fully his inestimable value to the college and to the world by his services as teacher, administrator, and scientist.

My great ambition is that I may prove to be a worthy successor to the man whose name this observatory bears.

ADDRESS OF EDWARD B. VAN VLECK AT THE DEDICATION OF THE VAN VLECK OBSERVATORY.

This is the day that my father longed to see. For fifty long years he served Wesleyan University. When he came to the University, all science was included under the good old fashioned, though ill defined title of natural science, with the exception of astronomy and theoretical physics which were united with mathematics. Later physics was made a distinct department, but mathematics and astronomy remained united during my father's life time. To the end his title was that of professor of mathematics and astronomy. So far as I know, he was the last professor in an institution of high rank to hold this double title. And it was fitting.

For from immemorial times the two departments have been noted for their interaction. Thales, one of the ten sages of antiquity, was the founder alike of Greek mathematics and astronomy, while Hipparchus, the greatest of Greek astronomers, is credited with the invention of trigonometry. Ptolemy, Kepler, Euler, Lagrange, Laplace are only a few of the great names of the centuries famous in both mathematics and astronomy. Gauss, whose fame in pure mathematics can scarce be eclipsed, laid in the Theoria Motus, which my father loved above all to teach, the foundation of the mathematical theory of the heavenly bodies. I do not hesitate to characterize the era from the invention of calculus in the seventeenth century to about 1825 as the gravitational or astronomical epoch of mathematics, in which mathematics was the handmaid of astronomy.

No sign of the coming cleavage between these two departments of thought had even begun to appear when my father, almost immediately after graduation, went to Cambridge to begin his lifelong work upon the "American Ephemeris and Nautical Almanaç", which had just been instituted in 1849 with Benjamin Pierce as consulting astronomer. This brought my father for two years in early manhood under the influence of one of the notable men of the country. In Pierce the mathematical and astronomical talents were harmoniously combined. He stands out even today as the first productive American mathematician, an isolated, solitary figure. In astronomy his position is not equally unique. Yet, if I understand rightly, he was one of the three great influences which molded American astronomy, sharing with West Point Science and the Naval Observatory the glory of raising it to international celebrity, a position it has never since lost.

To-day how changed the relations of astronomy! On the purely theoretical side it tends to become, I think, increasingly a province of the pure mathematician, while on the experimental side it has been in good measure annexed by the physicist, it has become an astro-physics. Shall we say then that it has ceased to have a separate entity? By no means. It gives out its raw material to the mathematician and physicist, and takes it back enriched for its own development. Thereby it produces a most wonderful and perfect weaving of three scientific branches. It was the perfect beauty of this combination which had an alluring attraction for my father. It was fitting then that he should be professor of mathematics *and* astronomy.

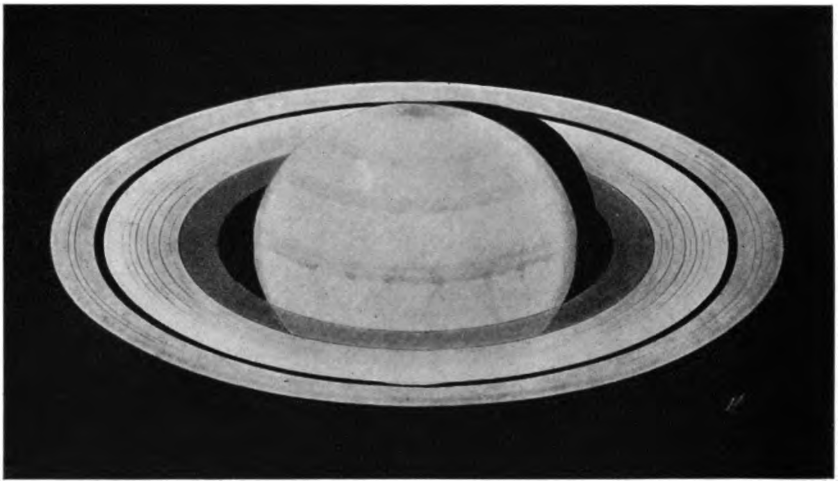
Yet, while this is true, his heart was in the astronomy. And why? Not alone nor chiefly because it was a combination of several sciences, but above all, I think, because of the manner in which it touches human thought and reveals Him whose abode is the light of setting and of rising suns. My father believed, as do many astronomers, that the greatest revolution ever made in human thought was that produced by the Copernican theory of the rotation of the planets about the sun. A like claim is sometimes made for Darwin's theory of evolution. With one stroke Darwin annihilated what men had conceived to be the infallible teaching of the Bible concerning the creation of the world and of man. For the fall of man he substituted the rise of man, for instantaneous perfect creation out of nothing he substituted ordered development and upward struggle. But great as was the change produced by what men termed in derision the Darwinian theory, its way was prepared by the Copernican theory and many another change in the four intervening centuries. For in Darwin's time there was freedom of thought. The scholar could say even as today, "*zu denken ist Gottes Dienst*"—to think is God's service. But the time of Copernicus was still the darkness of the middle ages. "Then the church had a rigid system of "dogma" and "philosophers a cast iron system of truth to match." The earth was the center of the universe. God sat on his throne in the upper story just above the clouds while hell was in the basement below. Copernicus burst forever these shackles of tradition and altered the entire conception of the world. More than this! While the later theory of Darwin leaves man on the topmost round of creation, in the universe of Copernicus he is abased into utter insignificance. Seen in the telescope even the sun and planets become as dust in the heavenly scales. The stupendous size of the universe hushes thought itself.

I doubt not that astronomy, like evolution, has made many an agnostic. It has made of man a Job vainly searching for an answer to the riddle of the universe. Can man by searching find out God? Yet, as has been so often said, an astronomer is reverent. As he scans the heavens night after night, a sense of harmony and reverence so fills his soul that agnosticism is forced out. "Hitch your wagon to the stars" is only a modern version of Isaiah's call "to lift up your eyes on high and behold who hath created these things." Astronomy is the foe of small thought. I do not know, I only wonder whether it was astronomy which developed in my father his great, his unusual love for truth, or whether it was his love for truth which drew him to astronomy. But this I do know, that its close connection with human thought was one of the reasons why he adored astronomy.

And there is another element in astronomy which made its strong appeal to my father, its romance. Every science has its romance, even mathematics, as I can testify. But is there another romancer such as the astronomer? His tales surpass the Arabian Nights in their appeal to the imagination. He crowds the pages of his science with wonderful stories of discovery and with startling surprises, and *these* myths can be believed by everydody.

Should not such a science as this be ever a popular and essential element of a college curriculum? Can any other science teach morals so unobtrusively? Has any other science an horizon so vast and ennobling? With the coming of Professor Slocum as Wesleyan's first professor of astronomy there opens here, I trust, a new era in which it will exist for its own sake. It is our wish and hope that my father's dream for astronomy and for the observatory may all be realized; for astronomy, that it may be an inspiring and much loved part of the curriculum; for the observatory, that it may be renowned for its research. My father entered not himself into this promised land. But for you, Professor Slocum, may these dreams come true.

PLATE XXV



SATURN—OPPOSITION 1914-15

From drawing made by Dr. Percival Lowell at the Lowell Observatory, Flagstaff, Arizona.

OUR SOLAR SYSTEM.*

PERCIVAL LOWELL.

Our solar system consists of a central ruling body, the Sun, around which circulate a number of smaller bodies called by the ancients "planets", which in greek means wanderers, because unlike the fixed stars they were seen rapidly to change their place. The study of this system is chiefly carried on at the present time by the observatory which I represent tonight. For today astronomy is largely specialized; observatories being stellar, solar, or planetary, as the case may be.

Of the origin of the system all we know is the birth-mark it bears of catastrophic origin, and that what we see today is the result of the shattered fragments coming together again. The proof of this lies in the telltale character of meteorites which are the *dei ex machina* in the matter. In a book called the Solar System, published many years ago, I pointed out a corollary from their character, to wit: That the fact that the meteorites held occluded gases which could only have got in under great heat and pressure; and that they had constituted the bricks from which our present system had been built, being themselves the left-overs, when considered together showed that a great disruption had preceded and furnished the material for the evolution of the solar system of today.

Of its career, subsequent to the collision or near-collision which gave it birth, we know only isolated bits. Many attempts have been made to decipher its history, but so far without scientific success. Thus Laplace's nebular hypothesis, which for many years in the early part of the last century had a great vogue, was long ago shown to be untenable. Faye in his "Origine du Monde" in 1884 exposed its fallacies and it was known to be in error long before that. Faye substituted a theory of his own and there have been many since, but we have no proof, and in several instances no reason to suppose, that any of them is correct. Scientists take little stock in such speculations, because of the lack of facts for basis.

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* Lecture before the Chicago Academy of Sciences, April 25, 1916.

We have, however, ground for saying what it probably was not. It probably bore no analogy, still less any distinct resemblance, to another type of evolution which we see in the sky, that of the spiral nebulae. Recent research has pretty well convinced scientists that we are there envisaging something quite different. This is indicated by the enormous size of these aggregations as shown by their apparent lack of parallax, which means their enormous distance off; secondly by their tremendous speeds, discovered at Flagstaff by Dr. V. M. Slipher, and thirdly the still later discovery by the same astrophysicist of their equally enormous rotary velocities, spins of a different order of magnitude from those of our solar system. In fact all we know and all we are daily learning about them imply that they are galaxies themselves in process of forming republics of stars and not absolute monarchies like the system of the Sun.

Of certain parts of our own evolution we are, however, well assured. From once scattered congeries of small particles, gravity has condensed the matter composing it into discrete bodies, each at its own distance from the central ruler. Curious relations between their distances lead us to believe that the planets themselves have had a hand in the arrangement and that what we now see is no haphazard result, but due to the forces brought into play by the several bodies during the period of the system's fashioning.*

Their several sizes are due first to the amount of matter originally at their disposal and secondly to the amount they were permitted to collect by the action of their neighbors. Their sizes once settled had in turn a determining effect upon their subsequent careers. Heated as these bodies were by the coming together of their meteoric constituents and their consequent contraction, the larger would necessarily take longer to cool and thus protract their life-histories. They evidence this, every one of them, today, complicated of course by other factors.

In this family our Earth holds a middle position in size and in relative age. It is now cool on the surface though still enormously hot within. The latter fact is proved by the increase of heat as we bore into it, and from the inevitable deduction that the gradient must continue to the centre; for by conduction the heat must spread in all directions and could not flow out to its full capacity until a down gradient to the surface were established from the core. From the necessity of this gradient we see that the process of accretion was not intermittent after the body had begun to cool, but took place practically once for all, long ago, while the body was still universally hot.

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* The Origin of the Planets. Memoirs of The American Academy of Arts and Sciences. Vol. XIV—No. 1.

Study of the system today makes this certain. There are no large masses of meteorites vagrant now and from continuity of process cannot have been for an excessive past. Glacial effects were local and are best explained by local elevations of the crust.

Principles acting continuously are our only trustworthy guides in science. As an example of the wisdom of pinning one's faith to general laws, I may take the case of Mercury. In the old textbooks, in Young's for instance, Mercury was described as the densest of the planets. Twenty years ago this struck me as theoretically impossible, since the smaller the body the less necessarily its self-pressure. Study of the planet by daylight showed in what the error lay, its diameter measured against the sky coming out decidedly bigger than the received one and search revealed that the older measures had been made on the body in transit—the sky-method having been at the average observatory impossible—and no account taken of the loss in the apparent diameter through the sun's irradiation into it. (About the same time its mass was slightly revised.) With the new diameter the density came out in strict accordance with the pressure law.

In none of its many branches has astronomy made greater strides in the last half-century, than in knowledge of the planets. So revelatory have been these discoveries as to introduce us to a new order of acquaintance with these bodies.

Flagstaff was specially selected as a site for such study because of the excellence of its planetary images. Far from the smoke of men it enjoys a climate which renders its air steadier than any so far found in the United States. This permits not only the detection of detail invisible elsewhere, but a precision of measurement of the detail detected, necessary to any accurate deductions from it. In consequence the art of observation has there been studied carefully, to the revealing of atmospheric and of optical conditions which, if not duly reckoned with, are pitfalls to precise results. Thus, simply to name one point, irradiation, till then left out of account in planetary measures, has there been shown to be vital to exactness.

To speak of all the planets would overrun the bounds of your endurance and of my time. I shall, therefore, confine myself to two, Saturn and Mars; the one typifying an early stage in planetary history, the other a far-advanced one. Compared with our Earth, Mars represents a cooler and relatively older world; Saturn a hotter and younger beginnings of one. Both planets are interesting as pointing in a general way to what our career was and to what it will attain. Saturn indicates, though with important differences, what we were; Mars points out with like foreshadowing what we shall become. This is one reason why Mars is to most of us the more interesting of the two. He is the future embodied, not the past revived. For the average person is more concerned with his coming track than he is over his wake. Furthermore we see in him the workings of physical laws in a field not too unlike our own, but freed from much of the complexity they are involved in on earth and decipherable therefore with greater speed and certainty. Then, too, in its evolutionary career a planet develops up, not down. With age it evolves higher and higher forms of chemic combination, ending finally in what we call life. Mars permits us in deciphering himself to read in advance a chapter in store for us in the great riddle of the universe.

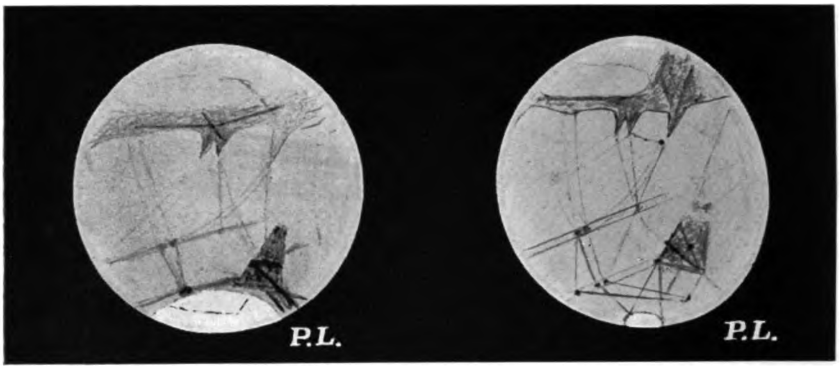
The two pictures I shall present to you are not exactly presentments of our particular career—for size greatly alters a body's cosmic course. A large body and a little one have not the same life-histories. But if absolute similarity be wanting, the very dissimilarities we note help us to a further comprehension of the cosmos and add a heightening interest of their own.

To a laymen probably the most impressive object in the heavens through a telescope is the planet Saturn. To see for the first time that great globe, girdled by its rings and set among a cortege of satellites, is a sensation as impressive as it is superb. Its light, its color and its symmetry all appeal instantly to the eye. The tiniest glass reveals it both beautiful and strange, while the largest does not exhaust its wonders. Thus quite a new order of detail has recently been discovered, both upon the ball itself and in the rings.

The first thing to catch the eye are the planet's belts. These are longitudinal stripes across the ball, suggesting broad natural parallels of latitude. They are easy to see and have long been known. When more minutely examined, however, they are found to be darker on the edges than in the centre, each thus appearing to be double. But the strangest of the ball's markings detected at Flagstaff are filamentous streaks between the belts, sometimes vertical but more often inclined, after the manner of the lacings of a sail. Individually they resemble distant droppings of rain from a storm cloud seen slanting against the sky under the force of a strong wind. At first they were described only across the light equatorial zone, but have since been seen meshing the whole surface of the disk. Were they not so faint they would yield excellent departure points for timing the rotation periods of different latitudes. For what we see of Saturn is not solid substance but a gaseous chaos in which each part is engaged in a go-as-you-please race with its neighbors.

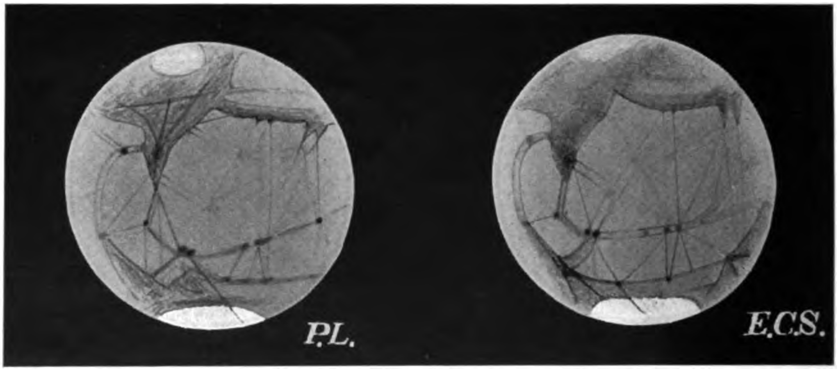
These wisps are not mere Saturnian oddities; they have a cosmic

PLATE XXVI



January 28 April 9

Rifts in snow cap where canals later appeared.



March 6 March 11

MARS IN 1916

From drawings made at the Lowell Observatory.

origin and intent. For they are found also upon Jupiter, which is in a similar stage of planetary evolution. Like the belts they are products of the axial rotation and of motions within the mass; only more intricately so. Why they are we do not yet know; that they are is evidently a necessary corollary of the forces at work.

Along the equator runs a narrow dark chord, like an outward visible sign of the dividing line where the forces reverse. This, too, is a cosmic feature, for Jupiter is similarly girdled. In fact, the surface markings of the one planet are a near-replica of the other's.

In its rings Saturn is unique. That the particles, meteorites, composing it are so close to the planet—within Roche's limit of the ball—prevents their coalescing into a satellite; the differential pull of the planet there exceeding the particles' own attractions for one another, so that they are pulled apart more than they are drawn together.

This appanage is not a single flat ring, but is made up of a great many narrow ones of different densities and different brightness, according as the particles are more crowded together. Outside of the outer one, circles the tiny satellite Mimas like a faithful watchdog guarding a herd of sheep. The simile is more than a figure of speech. For this diminutive body has actually caused the particles to arrange themselves in the several distinct rings. Furthermore, he has apportioned the numbers now found in each. He has in fact driven the rings into taking the form they present. When we compare his tiny twinkle with the broad expanse of splendor of the rings, such sway seems like the triumph of mind over matter. It more nearly represents the combined action of the particles of his mass against the lack of unity of the particles of the rings. For in a sphere all the particles act like a unit at the centre. It is the force of an army as against a mob.

In the case of two bodies disturbing one another as they travel round a third, the resulting effect is greatest when their meetings or conjunction take place recurrently at the same spot. This is because in such circumstance, whatever effect is produced is repeated over and over again—and, being cumulative, ends by being very large. The action may be seen in the case of an ordinary swing. If little pushes be applied rythmically at the same point of the path the swing rises higher and higher; if at all points indifferently, the pushes counterbalance one another to a nullity.

Now such similarly situated meetings will occur if the two planets have periods which are commensurate with one another, as 1 to 2 or 2 to 3. In such circumstances the disturbance grows until it ends in changing the periods of both so that they are no longer commensurate. In other words no planet will allow another to travel where its period would be a vulgar fraction of its own. Analytically the perturbing function is expressed in a series of periodic terms in the orders of the masses, m, m^2, etc. Now it is a property of the squares that they are necessarily plus, and therefore, contain constant terms. One of these constant terms changes permanently the mean motions, thus forever preventing fractional synchronism of period.

Now it is just where a particle of the rings would have a period commensurate with that of Mimas, that no particle is found, thus causing a division. All the important ratios are thus visibly sculptured into the form of the rings, featured in proportion as the force is strong.

Saturn and his suite are thus the embodiment of the laws of celestial mechanics in an early stage of planetary history. How beautiful their action, the sight of Saturn shows. It represents the apotheosis of mathematical form and yet the outcome of nature's simplest law, that of universal gravitation.

Quite another order of interest attaches to the second planet, the planet Mars. In it we find ourselves gazing at almost the antithesis of Saturn. Instead of a thick cloud canopy covering a seething mass below, we perceive a solid surface lying unveiled to view beneath a thin perfectly transparent air. We see it clearly revealed, far better than it ever can see us; the only bar to absolute definition being at times our own atmosphere, which in most places obscures, if it does not hide, what is certainly the most astounding sight in the heavens, the visible signs of intelligence upon another world. That the Martians should be led to doubt our own would be but natural, for our earth viewed from without presents even less evidence of mind than when considered more intimately from within. Nothing of men's handiwork would be visible to an observer placed on Mars. Our cities would shrink to nought, our railway lines be lost, everything revealing thought be swallowed up by distance. He might, perhaps, view the effects of our change of seasons but beyond that nothing.—Man's presence would lie unsuspected.

Quite otherwise is the aspect of Mars. Owing to its thin air it is possible in certain favored localities on Earth to see what is there going on. And that a great deal is going on is evident. Over a geography not unakin to the Earth's, is spread a mesh of lines and dots like a lady's veil. Only in this is it unlike that instead of hiding recognition the veil reveals it. For by its striking geometricism, it at once suggests artificiality and taken in connection with recent research as to the planet's physical condition implies local directing mind.

This network has been universally confirmed by students of the subject suitably equipped with instrument, eye and atmosphere and has been recorded on thousands of photographs.

To show what these photographs reveal to an acute-eyed observer not otherwise connected with them, there is here presented a drawing of the markings visible on the latest of them, that of March 15, 1916 The drawing was made by Mr. G. B. Hamilton, M. A. of Cambridge, England, F. R. A. S. and at one time assistant in the University Observatory, Oxford. It depicts 39 canals and 16 oases, the former as fine lines, the latter as dots, both presenting the same stamp of artificiality they display to the eye, when due regard is paid to the limit of precision imposed by the grain of the plate. Lack of a knowledge of photography alone is responsible for any failure to see them as geometric lines by inducing the observer, in hopes to see them better, to magnify them too curiously with a glass, to the obliteration of everything but the grain. It is then a case of not seeing the wood for the trees. Nothing perhaps better points the truth of the French aphorism—"Better is the enemy of good." To view them well, one should regard them with the eye of youth as they are presented on the plates, when their linear character and fineness will start to his vision at once. That photography should be able to record such delicacy of detail is certainly marvellous, with the planet at the time 75,000,000 miles away.

A prevalent misconception, largely bruited in not-expert writing on Mars, is that his near oppositions are best suited to detection of his canals. This is an example of the little learning that is so dangerous a thing, for the facts are largely the reverse. Were other things equal, when Mars is nearest the earth, he would be best seen. But other circumstances are not equal; for it so happens that the earthward presentations of the hemisphere where and of the season when the canals are most visible, occur together during his far approaches. Persons not conversant with the planet though very conversant about it, neglect those opportunities, devoting their efforts to the near and difficult oppositions.

The opposition which has just taken place has been one of these generally neglected but revelatory occasions. Several interesting phenomena have disclosed themselves on the planet's surface; some strikingly corroborative of what we already knew, some new which were unsuspected before.

Of the first class has been the evident consequence of the canal development upon the melting of the polar snow. This dependence has been markedly displayed during the last few months. It was just the Martian season to show it and the planet's surface has presented it to us. On October 18, 1915, the date of the planet's vernal equinox of the northern hemisphere, the northern snowcap was very large, coming down to latitude 60°, or thereabouts. Only right near its edge were any markings conspicuously dark. By January 1, 1916, the Martian date being April 25, the cap was in active process of melting and the north temperate canals were dark while those in the north tropical and equatorial regions were almost invisible. Two months later, a month in Martian chronology, these latter had begun to stand out. The seasonal change in them is well shown on comparison of two drawings, the one made on January 28 and the other on March 2, the former depicting Aeria as an almost unbroken stretch of ochre desert, the latter recording it as traversed by the faint beginnings of the great double canals for which it is famous.

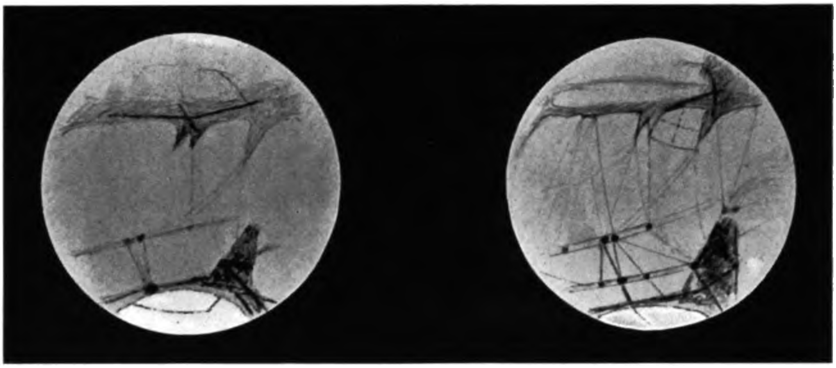
At the same time the canals in the dark regions of the southern hemisphere had been fading out and the Mare Tyrrhenum had turned to a chocolate tint, in contrast to the blue-green hue it had worn before.

And yet during this interval the planet had been getting farther away from us so that, had no intrinsic change affected the markings, they should have been less, not more, salient than before. Thus nature obligingly removed any possible doubt of the real accentuation in them while at the same time it offered, in the southern dark regions, a background on which to judge of their canals' obliteration, the more so that those regions themselves were fading out and were so wide that distance had no effect upon their general evidence.

Such canal development upon the melting polar snows was precisely what the theory framed here of the planet's present state had predicted.

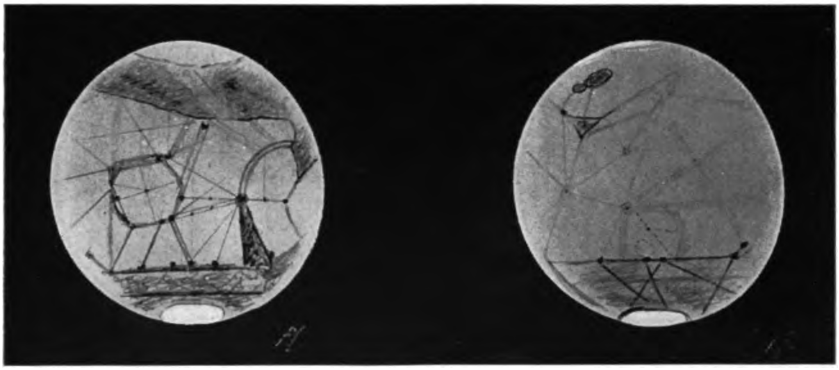
Of the second set of phenomena, those never before sufficiently seen to be properly appreciated, was the detection of a set of markings so minute as to constitute a new order of Martian features. Though individual instances of these remarkable showings had been previously detected here, they were not numerous enough to disclose their generic character. Spun, as it were, across the areolas of the planet's surface, made by the intersection of the main canals, appeared what may be likened to spider webs with the spider itself at the centre. For in several of the canal-bounded polygons a diminutive dot appeared, roughly speaking, in the center of the space, from which stretched filaments binding it to a corner and to the sides of the areola. Curiously enough the southeast thread, that joining the dot to the corner was the most salient of these ligatures and therefore the one detected first, though apparently it was no longer than the ones going to the sides. This web upon a web was first descried in Elysium and subsequently in Arcadia, while the Fons Juventae with its spokes proved to be of like character. To symbolize their peculiarity and position, the distinctive word Fons has been given them. Thus there is the Fons Immortalis in Elysium and the recent Fons Senectutis in Arcadia. While the

PLATE XXVII



January 28 March 2

Showing Canal Development.



March 15 March 27

Showing the new order of markings.

Mars in 1916

From drawings made at the Lowell Observatory.

spokes are called Viae, as the Via Vitae leading to the Fons Senectutis, and the Via Eterna to the Fons Immortalis.

So tenuous are these spoke-like filaments that they usually first appear as straightly aligned fine beads, becoming continuous lines only on still better seeing. The seeming beads are very small, finer than the Fontes which are themselves very minute, being only about ⅓ the diameter of the usual oases. The usual oasis, as near as may be judged, is about a degree of Mars or 35 miles across; so that a breadth of 10 miles for the Fontes is probably an outside limit. What they are we do not know. But that they are important points in the intelligent life of the planet is evident. For we should be careful not to assert more than science can affirm. All we can say at present is that the spot is clearly some sort of goal, the spokes pointing it out as an objective; while the lines to it differ in intent from the system of great canals which are through lines of communication.

Other detections of the last few months might be mentioned but I have said enough to show how our knowledge of Mars steadily progresses. Each opposition as it comes round adds something to what we knew before. It adds without subtracting. For since the theory of intelligent life on the planet was first enunciated 21 years ago, every new fact discovered has been found to be accordant with it. Not a single thing has been detected which it does not explain. This is really a remarkable record for a theory. It has, of course, met the fate of any new idea, which has both the fortune and the misfortune to be ahead of the times and has risen above it. New facts have but buttressed the old, while every year adds to the number of those who have seen the evidence for themselves. Astronomy is successive evolution simultaneously shown. In this brief sketch of bits of planetory history we have considered but two links in the long chain, one near the beginning, the other toward the end.

THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

[*Continued from page 354.*]

The apparent depression of the spots, which many years later gave rise to the famous Wilsonian hypothesis and its resulting controversy, evidently occupied a great deal of Scheiner's attention and time, for he refers to it many times in his great work. Von Braunmühl asserts* that Scheiner had already observed the apparent depression of the spots, and that he should be credited with the discovery of this phenomenon instead of Wilson. But Carrara† and Schreiber‡ show that this is an error. It is true that Scheiner speaks of the "depth" of the spots, but further investigation will show that the depth referred to, means thickness, and not depression. Scheiner frequently expresses himself with considerable uncertainty on this question, but this is doubtless because he was endeavoring to make his statements agree with the observations, which were themselves contradictory. Sometimes one may think that he considers the spots as elevations, other times he refers to the spots as depressions. But if one collects all the statements together and has regard for his terminology, and considers whether he is referring to the spot as a whole or only to the nucleus, the intent is evidently the following:

1. The spots certainly are not depressions in the sense of cavities or holes.¶

> The body of the spots are not dark depressions, fissures, gaps or dark openings.

At another place,‖ he states that the spots appear to be holes in the luminous surface through which we sometimes view the dark body of the sun. He then wonders, if such is the case, why it is, that the darkness is not illuminated by the surroundings which are bright; also why the faculae generally follow the spots instead of uniting over them. Further, at their entrance and exit (on the disk) the spots ought to be completely hidden by the surrounding faculae.

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* *Op. cit.* p. 63.

† *Op. cit.* **24**, 75.

‡ *Op. cit.* p. 88.

¶ *Rosa Ursina*, p. 510.

‖ *Ibid*, p. 500.

2. Scheiner believed that the observations would be best satisfied if it were assumed that the spots were situated at the level of the sun's surface. If his views are collected, one will find that he believed that the spots were definite material bodies or masses, of greater density than the surrounding medium in which they were imbedded, and which Scheiner believed to be of the nature of a fluid.*

> The body of the spot consists of a solid [that is, as he himself states, three dimensional] dark, opaque body, which projects at the most only slightly beyond the luminous surface of the sun.

He remarks† that in virtue of their mass the spots have a real depth, that is, extend under the surface. Concerning this surface he writes:‡

> I do not place the spots at such a depth [in this surface] that they are entirely immersed; for one spot may project more or less than the others, just as all ships in the sea do not sink to the same depth. For this reason, I always state that the spots are found on the physical surface of the sun, which is not to be considered as a mathematical surface, devoid of thickness, but as a surface possessing a real thickness, in which, and by which, the spots are carried by the rotation.

Regarding the projection of the spots beyond the surface:¶

> It is readily apparent that most of the spots project at least slightly beyond their surroundings, for, on account of their positions they obscure the luminous spaces between them when near the limb, so that two, three or more appear as one, which would not be possible if they did not project somewhat beyond the surface. I say that most of the spots, for sometimes large ones are suddenly overwhelmed with light before they reach the limb so that they can no longer be seen, and instances of this kind offer a strong argument for the opposite view, for one cannot easily assume that they always physically dissolve, but instead is forced to the opinion that they have sunken all at once in the luminous ocean. There can be no doubt that such spots lie deeper in the luminous surface, or that the latter is more elevated.

In another place we find:||

> The exterior surface of the spots is hence very much compressed and nearly flat.
>
> From the observations themselves, up to now, we have shown that the convex surface of the spots projects toward us hardly a sufficient amount to permit us to observe their elevation beyond the circular edge of the sun.§

Further, Scheiner believed that for circular spots the curvature is approximately spherical, but different from those that are not regular.

3. Scheiner believed that in contrast to the penumbra the nucleus lay at a lower level than it. He remarks** that it is

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* *Ibid.* p. 510.
† *Ibid.* p. 485.
‡ *Ibid.* p. 551.
¶ *Ibid.* p. 511.
|| *Ibid.* p. 484.
§ *Ibid.* p. 493.
** *Ibid.* p. 505.

> Wholly submerged in the penumbra, both as regards all its dimensions and the whole of its mass.

The nucleus was a real body to him,—not an empty hole—and this body extended deeper than the "less dense body" of the penumbra. Scheiner believed that the penumbra extended somewhat like an arch over the surface of the sun, and that the nucleus was similarly convex, and sufficiently so, that in spite of its deeper position it could still be seen when the spot was near the limb.

Although Scheiner never in so many words explicitly upheld the theory subsequently advanced by Wilson, and as he only expresses himself with hesitation, neither can it be said that he directly opposed it. He sometimes places the nucleus at a lower level than the penumbra, but then only slightly lower, and this only for occasional spots. He considers it an established fact that:

> ..... at a position near the limb, the spot presents to our eyes that portion of its penumbra which lies between the observer and the nucleus, and which cannot be distinguished from the nucleus, until by its motion the spot is optically extended and is seen in its full length.*

This is directly opposed to the Wilson hypothesis. At the limb a fairly regular spot appears like a line parallel to the limb, or even as a segment of it.

> From this phenomenon it follows that the exterior surface of the spot does not differ greatly in curvature from that of the solar surface itself .....otherwise it would appear distorted.†

The doubtfulness with which Scheiner expressed himself in discussing whether the spots are depressions or not, indicates one thing at all events, namely, the careful and painstaking manner with which he made his observations. Similarly it indicates the caution which he exercised when refraining from making assertions which could not always be supported by the evidence of the observations. If we regard the conflicting observations which have since been made by so many astronomers, and the controversy which waged for many years, we will no longer wonder that Scheiner was puzzled and became hopelessly confused in attempting to formulate a theory which would agree with the observations.

Johann Fabricius seems to have been the first to have mentioned the penumbra, but it was evidently seen indistinctly by him. Scheiner, however, was the first to give an accurate description of it. Long before the publication of the *Rosa Ursina*, in the letter of January 16, 1612, addressed to Welser, he writes:‡

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* *Ibid.* p. 501.

† *Ibid.* p. 482.

‡ *Gal. Op.* 5, 48.

> The boundary of all the spots is rough, as if surrounded with little fibers of white and black; and the majority of the spots are brighter about their borders than in the center.

That Galileo had also noticed the penumbra at an early date is clearly indicated by a remark in the first letter to Welser:*

> They [the spots] easily change their shapes, which in certain parts are more dark and opaque; and in others are less so.

In the drawing which accompanies this letter the penumbra is clearly shown as a shaded region surrounding the nucleus of the spot.

But as might be assumed, the *Rosa Ursina* contains the greater amount of material descriptive of the different portions of the spot. Some of Scheiner's remarks will be of interest. He writes:†

> I have found three kinds of spots, one kind have nuclei, and indeed they are very distinct; the other kinds, excluding the nuclei, resemble vapors, or fog, or smoke.
>
> Every spot is provided with a nucleus, which is surrounded by a definite body less dark and brighter than the nucleus itself.‡
>
> The border or boundary of the spot is neither continuous nor uniform, nor sharply defined; but instead it is varying, rough, broken and gradually disappearing; at the place where it meets the bright surface it appears as if fringed by the mingling of bright and dark from each side. Indeed certain spots appear from time to time whose borders remain the same while the spot is visible, as is the case, for instance, with circular spots. Since however, this very seldom occurs, and then only as long as the spot remains in a condition of quiet, one must judge from the usual appearance......This much, however, remains fixed; the borders always appear like contours or line drawings, either curved or straight, or both combined......always rough, jagged, indented, as if woven with fine threads: and moreover this phenomenon never remains the same in appearance or position, or form, but always shows the greatest variations.¶

This detailed and comprehensive description will doubtless be subscribed to by every astronomer who has observed the surface of the sun. One realizes from Scheiner's descriptions that his instruments were not as deficient in defining power as one might have supposed; and that the sun-spots appeared to Scheiner's eyes much the same as they appear to our own. Regarding the relative positions of umbra and penumbra, Scheiner remarks as follows:‖

> The exterior border of the penumbra agrees with the position and aspect of the nucleus, so that when the nucleus increases in one direction, the penumbra also increases in that direction, but always with the peculiarity that the penumbra increases toward the east rather than toward the west; so that sometimes the nucleus pushes itself out toward the west almost entirely denuded.

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* *Gal. Op.* 5, 106.
† *Rosa Ursina*, p. 156.
‡ *Ibid.* p. 510.
¶ *Ibid.* p. 513.
‖ *Ibid.* p. 210.

The fact that the nucleus is not always centrally placed in the penumbra, did not escape Scheiner, as is evident from his remarks. He further states:[*]

> The nucleus is not always placed accurately in the center of the spot, as I have already remarked; instead it is sometimes to one side. The body of the spot advances with its western edge before, so that it simultaneously trails after it the lighter portions of the spot.

This remark informs us that Scheiner perceived not only that the nucleus was sometimes eccentrically placed, but also that the nucleus of the spot tends to advance (in the direction of the sun's rotation) trailing after it the penumbra and the smaller "spotlets"; a fact of which all solar observers are aware. This tendency Scheiner noticed particularly in spot groups.[†]

> Seldom does a large spot appear alone, which, for a time at least, is unaccompanied by other spots; these often precede, but more frequently follow it.
>
> The nucleus strives and strains toward the west, which is customary with large spots.[‡]

Of even greater interest to Scheiner was the manner of formation and disappearance of the spots. Here we find that Scheiner was nearly as well acquainted with the life history of the average spot, as are his successors among the Jesuit astronomers of today. The process of spot disappearance received more attention than did that of spot formation; this was the obvious result of the ease with which the disappearance could be observed as compared with the inconspicuous beginning. He describes the manner of formation thus:[¶]

> After I learned this [the manner of disappearance], I began also to investigate the formation of the spots and found great similarity between their formation and disappearance. For I perceived for newly forming spots, as if it were premonitory, very fine shadings like cobwebs, spread over the sun's surface, which were only visible when one moved the telescope. In the course of a few days these shadings gradually became denser, developed into spots and remained constant. On this account I am accustomed at the beginning of each observation to examine the whole sun, moving the telescope while so doing. If I should notice such a shading, which seems to indicate a spot, I determine its position, magnitude, and appearance, recording also whether it is thin or dense, regular or irregular. In this manner I can be assured of observing the beginnings of many spots, although I acknowledge I sometimes stumble on secondary spots......I found in a similar manner that small spots separated from each other, broke out like blisters, gradually widened and united into a whole, increased in size, remained constant for a time, then decreased and in a similar manner disappeared.

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[*] *Ibid.* p. 491.
[†] *Ibid.* p. 516.
[‡] *Ibid.* p. 260.
[¶] *Ibid.* p. 536-537.

Regarding the development of the nucleus, Scheiner writes:*

> Frequently one single nucleus develops from the many small separated nuclei of a large spot; not by running together or local commingling of the single spots, for their centers retain their mutual distances, but through the intervening spaces becoming filled with similar material [to the umbra] or through increase in size without change of position.
>
> Similarly two or more small nuclei develop from one large spot, not through local displacements of the individual parts, but through a sort of vanishing of the material between them.
>
> Some spots at first show certain small, indeed diminutive, signs of their existence, as if they had come up from the depths of the sun; very faint at first, they gradually increase in size and density, and when they have attained the appearance of a spot, they become darker in the middle and the beginnings of the nucleus are seen, which then increases like the whole spot. Sometimes, however, many little spots move forward at the same time, but gradually; sometimes they rapidly melt into one spot and immediately develop a nucleus.

In similar detail Scheiner describes the disappearance of the spots.†

> Many spots decrease in size and at the same time undergo a diminution of density, so that only a delicate shadow remains, which differs so little from the rest of the sun's surface that it can be noticed only when moving the telescope, and such dark traces remain sometimes for one or two days, but more often they soon vanish completely. And indeed, a facula is frequently seen at the place; many times none is seen. In short, if one were not sure that a sun spot had been at this place, he would certainly not risk asserting that this phenomenon was the last trace of one.

Scheiner describes the small variations in the process of dissolution which he had witnessed, and continues:‡

> Finally many spots appear to be gradually inundated by luminous material from all sides, the luminous material spreads itself out, the spot decreases in size until no trace of a shadow remains, and only a bright facula is seen .....This manner of dissolution is very frequent, and differs from the first, as follows: in the first case the darkness of the spot gradually decreases......but in the second, the inundating luminous material hides the whole spot from sight, even if it may have a large and well defined nucleus, until all the darkness has disappeared, and only a bright facula remains. ¶

One point is of particular interest, for it shows the care with which Scheiner made his observations; it has also occasioned some discussion among latter day astronomers. Scheiner maintains on the evidence of many observations‖ that faculae frequently succeed spots and spots again succeed faculae at the same place on the sun's surface. He also noticed that spots occasionally reappeared at the same place, and in a particular instance remarks that this "is not an unusual occurrence with other spots."* Briefly, one finds that the facts regarding the growth and decay of the sun-spots, which we have learned with our improved modern apparatus, were also known for the greater part to Scheiner, who described them with great detail and skill, citing numerous observations as evidence.

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* *Ibid.* p. 498.

† *Ibid.* p. 535.

‡ *Loc. cit.*

¶ According to Scheiner's observations these faculae are distinctly larger than the original spot whose position the occupy.

‖ *Ibid.* p. 230.

The question of the duration of the spots also occupied Scheiner's attention. It appears that he believed that no spot endured for more than two months,† which seems peculiar, for he mentions spots which apparently were visible for more than two rotations. Three periods were distinguished in the life history of a spot. 1. From the first appearance to full growth. 2. The constant state, or period of apparent quiescence. 3. The period of dissolution or decay. The results of Scheiner's observations regarding these periods are as follows:‡ Although the duration of the constant state is very variable, in general it is proportional to the period of growth; that is, a spot which appears very suddenly does not long remain in the quiescent state, but progresses rapidly to disappearance. To this, however, there are exceptions. The disappearance or decay usually progresses gradually, but may vary considerably; in general, however, the period from full development to final disappearance is about twice as long as the period of growth. The size which the spot may attain has no relation to the time required for development.

The observations of the longest enduring spots are of interest.¶ At the time of the earlier observations the question had occurred to Scheiner, whether or not a spot might sometimes become visible a second time because of the sun's rotation. It was evident that many fully developed spots passed beyond the limb without undergoing any extensive changes, or otherwise indicating immediate decay. Scheiner believed that it would be difficult to prove the identity of a spot, even if it should return. At that time, not being fully cognizant of the law of the sun's rotation, he wisely concluded to wait until more evidence could be obtained, judging that this would be the safer course. Scheiner showed his wisdom in waiting many years before expressing himself in this regard. He mentions instances of four spots which were visible for two rotations, to show by their aid what criterion should be followed in investigating such spots. He correctly placed small confidence in the mere appearance of the spot, but made the proof of identity rest on the position of the spot on the sun's surface, and on the interval between disappearance and reappearance. While employing this method of identification he by no means overlooked the possibility of a spot disappearing when on the other side of the sun, with the immediate appearance of another spot at the same place. He remarks concerning the improbability of this, as follows:[*]

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* *Ibid.* p. 264.

† *Ibid.* p. 592.

‡ *Ibid.* p. 490.

¶ *Ibid.* p. 546.

> It is inconceivable, not to say impossible, that this spot recently appeared at the place of a former one, which must have vanished. For that one passed off the limb while in a state of development, while this one appeared at the limb in a state of decay.

At another place he argues,[†] that if it were a new spot, a very large and extended spot must suddenly have disappeared, and another developed very suddenly in the same place, remaining afterward for a long time, "which is contrary to all experience."

Thanks to the accurate determinations of the positions of the spots, Scheiner was able to recognize the individual, or so-called "proper motions" of the spots, and to perceive that these motions had no connection with the general motion produced by the sun's rotation. Schreiber[‡] asserts that Scheiner was the first to mention these motions in his *Rosa Ursina*. This seems to be an error. There is no question but that Scheiner discussed these motions very completely, and mentioned numerous instances of them among his published observations, but it is equally certain that Galileo had at an early date perceived precisely the same thing. At the beginning of the second letter to Welser, describing the phenomena of the spots in general, Galileo writes:[¶]

> Besides these irregular and individual motions of uniting and separating...... they have a common and universal movement......

Scheiner measured these proper motions, determining their magnitude and direction. Of the motions in longitude he cites many instances, which are completely described and illustrated in the drawings. He repeatedly mentions:[||] "the increase in the distance between two spots on the same parallel." That there should be no doubt of the reality of this, he remarks in another instance:[§] "with this in view I gave the matter great attention." In a very much disturbed group two spots separated in a manner: "absolutely unbelievable." In discussing two spots visible during April 1626, he remarks: "Their paths were nearly in the same parallel, and their mutual distance remained constant (which is very unusual in this phenomenon)."

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[*] *Ibid.* p. 206.

[†] *Ibid.* p. 216.

[‡] *Op. cit.* p. 154.

[¶] *Gal. Op.* **5**, 117.

[||] *Rosa Ursina*, p. 188.

[§] *Ibid.* p. 184.

The tendency of two sun-spots to separate, as if mutually repellant, which is generally supposed to be a more recent discovery, is thus seen to have been well known to Scheiner. He states it as a general rule:*

> The spots at their beginning are always closer together, and only later do they begin to separate from each other.

He again asserts in the discussion of the observations of a spot seen March 1625:†

> It is noteworthy (a fact which I have often remarked) that the spots at first are only separated by a small distance, which increases day by day, so that at the time of their disappearance the intervening space has not returned to its size at the beginning.

Displacements in latitude were also noted. He mentions many instances; in one such he states;‡ "Similar phenomena, namely, convergence and divergence of the paths of two sun-spots are often seen." Two spots, whose paths actually crossed he considered;¶ "an unusual but not unique occurrence."

Of greater interest are the discovery and observations of the faculae. It is asserted by von Braunmühl,‖ by Schreiber,§ and even by Favaro that Scheiner was the first to observe the faculae. Carrara, however, has shown in a most convincing manner** that this is an error which may be traced to the incorrect translation of a certain passage in Scheiner's letter of January 16th to Welser. It is true that in this letter the word "faculae" is used, but as Carrara shows, it is with an entirely different meaning from that which it has today. To Galileo unquestionably belongs the credit for first observing the faculae. In the third letter to Welser (dated December 1st, 1612) we find these words:††

> In the face of the sun itself there are sometimes seen certain small regions which are brighter than the rest......and I believe that no one can doubt that these are in the sun itself, it being incredible that outside of the sun there should be found any substance more luminous than itself.

According to Carrara, Scheiner's first mention of the faculae as such is in the *Rosa Ursina*‡‡ where he relates the circumstances of an observation made on the 21st of December 1624, as follows:

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* *Ibid.* p. 294.
† *Ibid.* p. 188.
‡ *Ibid.* p. 330.
¶ *Ibid.* p. 264.
‖ *Op. cit.* p. 17.
§ *Op. cit.* p. 156.
** *Op. cit.* **24**, 80.
†† *Gal. Op.* **5**, 219.
‡‡ Page 163.

> I and R. P. Ioannes Baptista Staserius, at that time a mathematician of Naples, the sky being most clear, examining the sun most carefully by moving the telescope, found it free from spots, but dotted with brighter regions which I call "faculae."

Carrara expresses surprise that Scheiner had not observed the faculae before this date, and discusses at length the probable reasons. However, if we can believe the testimony of Welser, Carrara is in error on this point. There is preserved a letter from Welser to Galileo, dated October 18, 1613, in which is quoted a portion of a letter, evidently from Scheiner mentioning and describing the faculae. Welser writes as follows:*

> Since you like to hear of the discourses of my friend [Scheiner?], I copy what I have recently received from him concerning some new observations.

Welser then quotes as follows:

> Since you ask of me what phenomena I have recently seen in the sun, there is no reason why I should refuse your friendly and just request. I add, therefore, an observation [a drawing which is reproduced in *Gal. Op.*] made on the first day of August, in which you will see examples of this new sight. However, these are not sun-spots, but are "little torches" (faculae), that is, regions which are brighter than those surrounding them, so that they shine more brilliantly than these......Nor is there any reason to doubt at all concerning this thing, for I have noticed its appearance for more than a year; first, by inspection, then much more clearly by projecting with a tube on a card. Many other people unskilled in this thing saw it with me also.

The letter continues, describing the experiments that were made with the telescope and card to prove that the faculae were not caused by the apparatus. Scheiner then remarks:

> They appear more rarely and less often than the spots themselves, and indeed, they are only visible at the margin of the sun, at ingress and exit, and then for a space of three or four days, but never in the middle [of the disk.] They are seen with difficulty, and only with a very good tube, and by moving the sun's image when on a card. Other things they have in common with the spots. What they are, I do not know.

There is nothing to inform us from what writing of Scheiner's this is quoted, but it seems safe to assume that it is from a letter to Welser, all traces of which, however, seem to be lost, for there is no other mention of it. If the statement of Scheiner, that he had been observing the faculae for a year, were true, it would place his observation as early, if not earlier than Galileo's. But as this depends upon Scheiner's statement alone, with no other evidence, it can hardly be considered an established fact. But there is no doubt that Scheiner had observed the faculae previous to the date mentioned in the *Rosa Ursina*. Whatever credit may be attached to the introduction of the word "faculae" belongs to Scheiner.

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* *Gal. Op.* **11**, 587.

If not actually the first to observe the faculae, Scheiner certainly observed them more carefully than did Galileo. Among the facts, which he ascertained as a result of his many observations, the following are worthy of mention.

1. The faculae are not confined to the spot zones. Numerous instances of this are given among his observations; he also states explicitly that the faculae are found in the high latitudes.*

2. The faculae are not all of the same brightness or intensity; many are very bright, intense, and brilliant, others are as if smoked or deadened. †

3. They differ greatly in size, oftentimes covering immense areas. The length of one group visible during April 1625 was equal to one-quarter of the sun's diameter.‡

4. The faculae show a tendency to spread out more toward the east limb than toward the west. Hence the faculae which appear in the neighborhood of spots generally follow them. This fact is repeatedly mentioned. ¶ In every case there are more faculae in the rear of a spot than in front of it. ||

5. The faculae are subject to change even more than the spots. § "This I have learned through accurate and continuous observations for many years."

6. The faculae move in accordance with the same laws as the spots. This is demonstrated from observations of faculae which accompany spots, as well as from those which do not. "That these were faculae, was deduced from the fact that the movement of rotation of the faculae and the spots is the same." ** Scheiner established the identity of a group of faculae visible April 1625 on the east and west limbs, and from this determined their period of rotation. ††

It was also established by Scheiner that faculae were frequently seen at the position of a spot after the latter had disappeared, and in other cases that the facula preceded the spot. Concerning the alternate repetition of spots and faculae at the same position, one needs only to

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* *Rosa Ursina*, pp. 190; 304.

† *Ibid.* p. 156.

‡ *Ibid.* p. 206.

¶ *Ibid.* pp. 248; 260; 268; 292.

|| *Ibid.* p. 192.

§ *Ibid.* p. 202.

** *Ibid.* p. 190.

†† *Ibid.* p. 204.

examine the index of the *Rosa Ursina* under the titles, "Maculae in faculas abierunt," and "Maculis e faculis," to appreciate that Scheiner had repeatedly observed this. He collects the results of 27 observations and remarks,* that one observes:

> .....the changing progression of faculae after spots and spots after faculae in the same place. I would not maintain this so eagerly for only a single observation if I had not found the truth of this to be most certain, and established by my own observations.

At an early date Scheiner had observed that the spots did not all move with the same velocity across the sun's disk. In the *Accuratior Disquisitio* † he describes the observations of two spots, one of which, crossing nearly on the ecliptic (through the center of the disk), required 16 days for its transit, while the other crossing farther from the center (as shown by a drawing) required only 14 days. Von Braunmühl states ‡ that Scheiner had at this time observed that the spots near the solar equator travelled with a greater velocity than those further north or south, and hence, had discovered the "Equatorial Acceleration." In this von Braunmühl is believed to have made an error. In the *Accuratior Disquisitio* Scheiner remarks:

> This is certain, that those [spots] which transit the middle of the sun, delay more under the sun, than those which turn nearer the edges......It is therefore manifest, that those spots which cross under the ecliptic—the sun's diameter—revolve longer under the sun than those whose path is farther away from it towards the south or towards the north. (Hoc certum, quae medium Solem transeunt, plus morae facere sub Sole iis quae magis ad extrema Solis vergunt......Manifestum igitur, eas maculas quae Solis diametrum eclipticam subeunt, diutius sub eo, Sole inquam, versari, quam eas quarum via ab eadem sive in austrum sive in boream recedit).

From these observations, Scheiner argued that since the sun was *invariabile et duro posito* the spots could not be a part of it, no matter whether it rotated or not.

In his third letter to Welser, Galileo discusses this observation and resulting argument, and replies: ¶

> Having made many careful observations of this thing, I have found not a single one from which we can draw any conclusion, except that all the spots indifferently remain on the solar disk for the same space of time, which in my opinion is something more than 14 days.

Galileo criticizes the observations of Apelles, because Apelles had observed not a single spot, but one spot of a large group, the relative positions of which might change, and hence a single observation, which would be subject to many accidental errors, would not be sufficiently reliable to determine such an important conclusion. The irregular motions of the spots are such that no conclusion can be drawn except from the comparison of many observations. As a result of comparing over a hundred drawings and observations, Galileo states:

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* *Ibid.* p. 230.

† *Gal. Op.* 5, 49.

‡ *Op. cit.* p. 19.

¶ *Gal. Op.* 5, 203.

> I have indeed met with some slight differences in times of transit, but I have noticed on the other hand that the spots moving in paths near the center of the disk are sometimes more rapid than those further away.

From this it is seen, that if anyone is deserving of credit for the discovery of the equatorial acceleration at this time it is Galileo. However, he did not recognize that there was a systematic decrease in the rotation period with decreasing latitude, but merely noted in a few instances that the equatorial spots apparently travelled more rapidly.

Evidently Scheiner's many subsequent observations showed him the true state of affairs, for he informs us in the *Rosa Ursina** that different spots have different rotation periods, and that the spots at a distance from the equator travel more slowly than those nearer to it. By this time Scheiner had recognized that the spots were adherent to and a part of the sun, and that the assumption of a solid sun was no longer tenable. He states:†

> From this phenomenon is drawn the strongest argument for a fluid surface of the sun.

This extraordinary phenomenon—the equatorial acceleration—was subsequently rediscovered and observed by Carrington in 1859. Its cause still remains, as in Scheiner's day, one of the sun's unsolved mysteries.

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* Page 260.

† *Rosa Ursina*, p. 559.

EVIDENCES OF EROSION ON THE MOON.

WILLIAM H. PICKERING.

The question whether water formerly existed upon the moon in larger quantities than at present is usually answered in the affirmative, but generally for wholly erroneous reasons. We often hear it stated that the so-called seas are simply old ocean bottoms,—a most improbable view. A casual examination of the lunar surface shows that they were formed at a period subsequent to the creation of the larger craters, since we find numerous of these craters partially ruined and dissolved in them, evidences of fusion being everywhere visible. The seas really owe their existence without doubt to extensive fissure eruptions, such as have occurred in past ages in India and in some of our North-western States. During this period extensive areas of the Moon's crust sank beneath the liquid surface and were dissolved in it, much as often occurs at the present time on a small scale in Kilauea, Hawaii. The bottoms of the great majority of the larger craters were also dissolved or softened at this time, indicating that the crust was thin. After this period was over, a second era of volcanic activity began. The craters produced, however, were much smaller than those of the first period, and indeed are comparable in size to some of our own larger terrestrial craters. They are found chiefly upon the maria and smoother crater floors, and may be recognized by their dark color.

That there never was very much water on the moon's surface is rendered certain by the lack of extensive areas of erosion. Nothing is seen at all comparable in extent to what an outside observer would notice in inspecting the earth under similar circumstances. It is probable that all or nearly all of the larger craters were originally furnished with central peaks, but in most cases these were destroyed when the floors were liquefied. Of the peaks which are left, doubtless all at one time, as in the case of our terrestrial volcanoes, gave out large quantities of steam and volcanic gases. On account of the rare lunar atmosphere, due to the small force of gravity, this moisture would have been immediately precipitated as rain or snow, so that the erosion would have been confined to, and concentrated about the vents.

In the lunar craters the only evidences of erosion are in fact found on these central peaks, but so marked is the effect in these places, that only a minority of the smooth cones of large size are left, while in the majority of cases we find that they have been partially cut, and sometimes almost completely worn away. By arranging the cones according to the denundation exhibited we may form them into a continuous sequence, and thus study the process nearly as well as if we actually saw the destruction going on before our eyes. To aid us in this endeavor we have arranged them in five classes as follows:—

(*a*) Cones exhibiting little or no erosion. Perhaps the best examples of this class are found in Alpetragius and Godin.

(*b*) Cones in which the ravines occupy less than one-eighth the total volume of the cones, Agrippa, Pallas.

(*c*) Cones where the ratio of volumes is one-eighth to one-quarter, Tycho, Eratosthenes.

(*d*) Cones where the ratio is one-quarter to one-half, Theophilus Maurolycus.

(*e*) Cones where the ratio is over one-half, and which are therefore divided into several portions, Copernicus, Aristillus.

In the following table 45 of the chief cones are classified under these five heads:—

CLASSIFICATION OF CRATER CONES.

a	*b*	*c*	*d*	*e*
Alpetragius	Agrippa	Albategnius	Bullialdus	Aristillus
Alphonsus	Arzachel	Eratosthenes	Maurolycus	Aristoteles
Doppelmayer	Burg	Miller	Piccolomini	Atlas
Fabricius	Herschel	Landsberg	Theophilus	Antolycus
Godin	Manilius	Langrenus		Clavius
Hahn	Mayer, C.	Plinius		Copernicus
Kepler	Pallas	Tycho		Eudoxus
Lilius	Taruntius	Vitello		Gassendi
Pitatus	Vlacq			Maginus
Römer				Petavius
Timaeus				Stevinus
Ukert				Werner

In the cases of Alphonsus and Pitatus the floors have been so deeply flooded with lava during the period of the great fissure eruptions, that only the extreme summits of the cones are left above the surface. Their very small size leads us to believe, were the lower slopes visible in their entirety, that they might properly be placed in one of the later classes, instead of in class (*a*). Although class (*d*) covers an erosion of a quarter of the total volume of the cone, yet it contains very few specimens. This indicates that the destructive agencies worked more rapidly when this stage of the process was reached. When the cones are near the limb, it is impossible to determine in which class they should be placed. Several large and well-known craters have been omitted from this classification on this account. In the case of Copernicus the original cone is now divided into three separate mountains. These mountains are but a vestige of the great central peak which formerly existed, and whose ruins lie scattered over the southern half of the floor.

The cross sections of the ravines cutting the sides of these cones are U-shaped, and not like a V. On the earth this would imply the action of ice rather than water. The same is doubtless true upon the moon, and this tells us that in those early days the lunar atmosphere was too rare to permit water to form in large quantities, for no river beds leave the bottoms of these ravines, the ice simply evaporated, after covering the floor of the crater. Unfortunately, as above mentioned, the original floors have in most cases been destroyed. This is shown by the smoothness and lack of detail exhibited, showing them like the maria, to have solidified from a liquid surface. When not actually melted, the floor has in many cases been softened, thereby destroying much of its original character. In those few floors that are left unchanged, or which have been only partly destroyed, we find the *debris* at the base of the cone is often radially disposed, the ridges on the floor accurately prolonging the sides of the ravines. So many instances of this occur that it cannot be due to accident, and no volcanic explanation seems available. These ridges are occasionally winding, as in Tycho, but usually they are fairly straight, as in Theophilus.

The only possible explanation for them seems to be that they are lateral moraines left by the great glaciers which have long since disappeared. They are shown in Copernicus and also in Arzachel, in both cases extending towards the south. In Pallas, Tycho, and Theophilus they extend towards the north. Such delicate detail is generally only shown by its shadow, so that it would be almost impossible to detect moraines lying in an east or west direction if such exist. Nevertheless, two lines of lighter color cross the dark floor of Bullialdus towards the west, from a ravine in the central cone. In this case when the floor was melted and mixed with darker colored lava from beneath, the lighter colored moraines seem not to have been entirely destroyed. A well marked moraine also crosses the floor south of the peak.

Although these great central cones have in most cases long since ceased to give out the vapor whose condensation worked their destruction, yet in a few cases some activity is still apparent, for we find the cone much the brightest portion of the crater, indicating that a little vapor is still emitted, and has fallen as snow upon it. Theophilus is a notable example of this fact. Piccolomini, Bullialdus, and Alphonsus also show bright peaks. These snow areas slowly change their size and shape, generally disappearing as the lunation progresses. On Bullialdus the imprisoned vapors do not seem to be released until after the sun has been shining on the peak for several hours. General brightening then occurs.

Theophilus exhibits the most interesting changes, however. The snow which at first covers a considerable area in continuous masses, by colongitude 34° begins to break up into separate patches, which change their shape and size notably as the lunation progresses. They grow smaller and smaller as the sun rises higher, and finally at about colongitude 110° the spots suddenly disappear and are replaced by a large faint continuous surface of freshly formed frost or snow. This in turn gradually brightens until sunset. It is like the formation in autumn of the new polar cap on Mars. It should be noted that as in the case of Pico, Teneriffe, and other lunar mountains, the snow in Theophilus at present lies only on the ridges and never gets so far down as the ravines. In the cases of both Theophilus and Alphonsus the central peaks soon become hazy due to the formation of cloud about them. This is most readily seen in Alphonsus on account of the small size of its peak. It can best be detected by a comparison with the sharpness of definition of some of the small craters upon their floors, but the observation requires excellent atmospheric definition.

For the benefit of those persons not having access to a good telescope working under favorable atmospheric conditions, it may be mentioned that these ravines and even the lateral moraines are well shown on a lantern slide of Theophilus taken a number of years ago at the Yerkes Observatory, and which was at the time pretty widely distributed. Two ravines side by side are seen on the northern side of the central peak, and from the two sides of the right hand of these two lateral moraines or ridges, indicated by the darker shading of the floor, are seen extending nearly due north to the edge of the crater floor.

In addition to the volcanic cones the riverbeds of the moon form another clear indication of former erosive action. Between thirty and forty of these are now known to exist, Harvard Annals **32**, 87. The most characteristic of them, and the one which is best seen, lies in a valley of the Apennines east of Mt. Hadley. It is shown in Plate 7 of the Harvard Annals **32**, and somewhat imperfectly in "The Moon", p. 43, by the writer. Two excellent examples also lie to the west of Plato, and north of the valley of the Alps. Another one lies to the east of Plato, and a very short one in its southern slope. In the Annals a riverbed in the northern part of Petavius is figured and described as at that time, in 1892, the "next largest after that upon Mt. Hadley." It is now only seen with difficulty after full moon, and it would almost seem as if some change had taken place in the mean time in this formation.

June 9, 1916.

UPON THE PROJECT TO ADVANCE THE LEGAL HOUR.

(From the address by M. Camille Flammarion, in L'Astronomie, June, 1916.)

"This idea of preferring morning's pure and sunny atmosphere to the night's mists is not at all new. 'Hours of morning, hours of gain', said an old proverb, before the births of any of us. None of us is yet 132 years of age; but in 1784 Franklin, who resided at Passy from 1776 to 1785, stated in the *Journal de Paris* that he was making a discovery respecting the customs of Parisians; that the sun shone upon us as soon as it rose, and that Parisians are not reasoning people. 'My liking for economy', said he in this article, recently brought to light by Professor Richet, 'has led me to make the following calculation: the six months from March 20 to September 20 yield 183 nights. I multiply this number by 7 in order to obtain the hours during which we burn taper or candle, and I get 1,281 hours. Since there are 100,000 families, I obtain 128,100,000 hours of consumption, which represents an annual waste of 96,075,000 *Tours livres*, in wax or tallow, for the whole of Paris (more than a hundred millions of francs)'.

"Although speaking in praise of the lamps of 'Monsieur Quinquet', the writer declares that he much prefers the light of the Sun.

"And in order to interest the Parisians in thrift, the illustrious philosopher proposes:

First, *To lay a tax of one louis upon every window which has shutters preventing light from entering when the sun is on the horizon.*

Second, *To ring all the church bells at sunrise, and, if that is not sufficient, to shoot off cannon in every street.*

"The idea which should predominate among us is that the 'hour' is merely a convention, a *fiction*, ever since the law in 1816 which substituted mean time for solar time. In the epoch of Louis XIV, also, did not the clock-makers of Paris take for a coat-of-arms a clock with this proud motto: *Solis Mendaces Arguit Horas*? 'It proves that the hours of the sun are false.' Solar dial-plates do not regulate any more the hour of day. Noon is no longer, since 1816—just a century—the middle of the day. In the department of Alpes-Maritimes the difference can equal three quarters of a hour, and at Menton night in winter comes at half-past three, p. m.

"Modern customs, besides, have unwedged life of more than an hour. Since the time of Louis XIV we have dined later and later; it is the same in going to bed, and, consequently, in rising. The meanings of the words themselves have changed. A theatre 'matinée' takes place from three to five o'clock in the afternoon.

"The active existence of governments, of offices, occurs between 8 o'clock in the morning and 6 o'clock at night. In the cities the whole daily life of the inhabitants is based upon this practical activity, the centre of which is not the noon, but an *hour.*

"This project of advancing the legal hour is a simple measure of economy, well worthy of attention at this moment, and, at the same time, well deserving of general hygienics.

"The economic saving would be general. Consider simply the post-office department. The advance of an hour diminishes especially the use of artificial light. It would be the same in all families, in most of the industries. The present coal crisis would be checked by it.

"On the other hand, what pleasure would all the workmen not have who until now have not been able to leave their desks, shops and factories till night, and who are not able to enjoy in the spring time some delightful hours at sunset!

"Certainly, the project is debatable from the strictly cosmoramic point of view. Although a convention, a fiction, the civil hour should depart as little as possible from the solar hour. The regulation of 1816 had already put perceptibly into disagreement solar sun-dials and clocks. The substitution of the Greenwich meridian for that of Paris, in 1911, has added nine minutes to the difference. The proposed new hour will increase still more the difference, particularly for western France; but this difference diminishes from west to east, and the departments of Bouches-du-Rhone, Var, Alpes-Maritimes, Hautes et Basses-Alpes, Savoie and Haute-Savoie, as well as the Vosges, Alsace and Lorraine, will find it in nearly their solar hour.

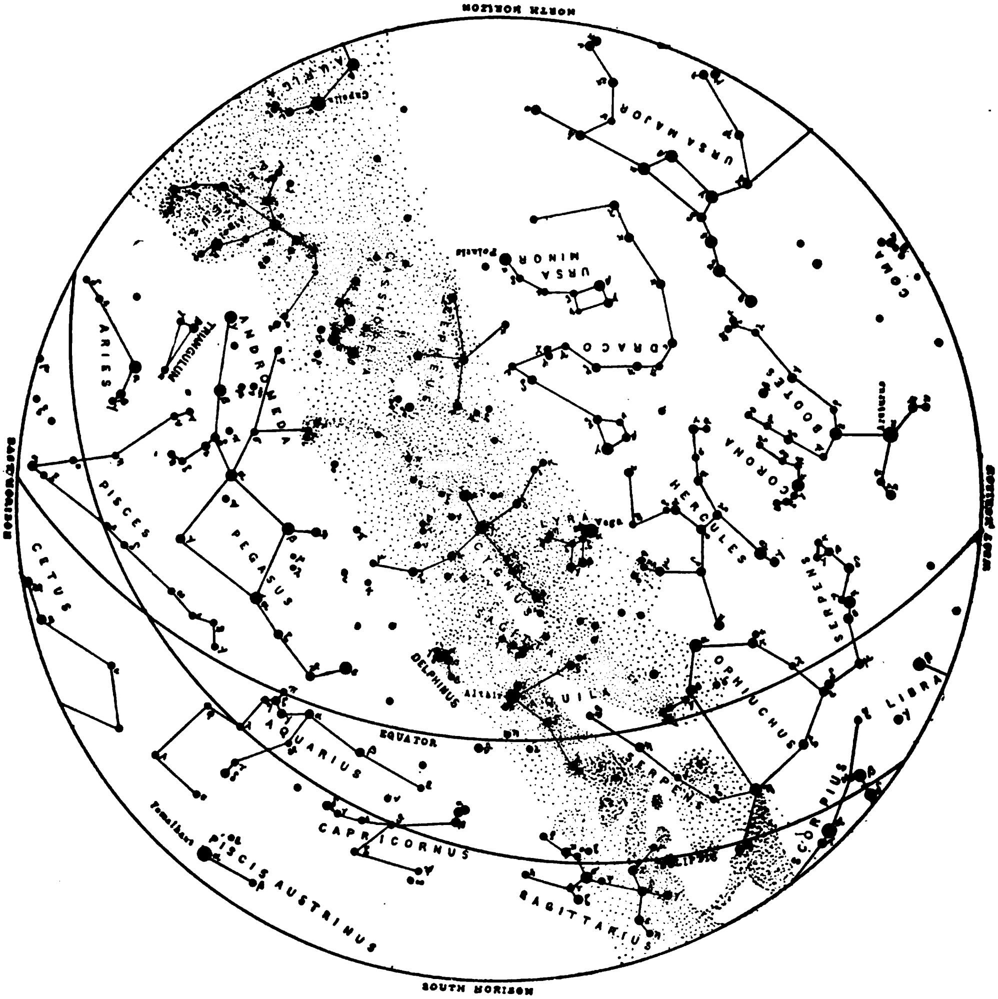
"Let us not forget that the *only true hour is the local hour* the solar hour, and that *the rest is pure convention.*

"One more word, gentlemen, in closing this presentation of the problem. When the inhabitants of our planet have, by chance, a good idea, they are incapable of preserving it. The question which agitates and divides us at this moment would never have been raised if mankind had kept the international and logical meridian of the island of Fer, adopted in our ancient charts, which, situated at the most westerly point of the European world, in the Canaries, is 20½ degrees from Paris, so that France will belong naturally to the second spindle of the 24 hours. But natural rivalries have spoiled everything. They have committed and commit indeed other mistakes,—and some stupidities perceptibly more serious."

Translated by CHARLES NEVERS HOLMES.
Newton, Mass.
41 Arlington St.

PLANET NOTES FOR SEPTEMBER AND OCTOBER, 1916.

During these two months the sun will follow a south-easterly course through the sky, crossing the equator on September 22, thereby marking the time of the autumnal equinox. It will begin this period in the constellation Leo, a little to the east of Regulus, pass through a region in which there are no conspicuous stars into the constellation Virgo, and end the period a little to the east of Spica.



THE CONSTELLATIONS AT 9:00 P. M. SEPTEMBER 1.

The phases of the moon for these months are as follows:

First Quarter	Sept. 4	at	10 P.M.	C.S.T.
Full Moon	11	"	3 P.M.	"
Last Quarter	18	"	12 P.M.	"
New Moon	27	"	2 A.M.	"
First Quarter	Oct. 4	"	5 A.M.	"
Full Moon	11	"	1 A.M.	"
Last Quarter	18	"	7 P.M.	"
New Moon	26	"	3 P.M.	"

Mercury will be visible twice during these two months. On September 9 it will reach a position of greatest elongation east of the sun. On and near this date therefore it will be visible in the evening sky. It will set a little south of the point of sunset at this date. It will be brighter than a first magnitude star and should be found easily. It will immediately move towards the sun and pass between the earth and the sun on October 4. It will then swing out to the west of the sun and become visible as a morning star a little after the middle of October. It will probably be visible during the remainder of the month.

Venus will be brilliant in the morning sky throughout this period. It will reach its point of greatest angular distance from the sun on September 12. It will then appear in the telescope as a half moon and will be very bright.

Mars will still be visible in the evening sky throughout this period. It will, however, not be in a favorable position for observation as it will be quite far south and will set soon after sunset. It will also be at a great distance from the earth and receding, consequently it will not be very bright.

Jupiter will be coming into favorable position during these two months. It will rise before midnight at the beginning of the period, and will rise earlier each succeeding night. By October 23 Jupiter will be in opposition with the sun, and will consequently be on the meridian at midnight. At this date it will have its maximum brightness, and will be very conspicuous in the eastern sky in the evening.

Saturn will rise before the sun during this period and may be seen in the morning sky at the beginning of September. By the end of October it will be rising about midnight.

Uranus will be well situated. It will cross the meridian about nine o'clock in the evening as an average during this period. It will be in the constellation Capricornus.

Neptune will not be far from Saturn during this period. It will be in the constellation Cancer.

Occultations Visible at Washington.

Date 1916	Star's Name	Magnitude	IMMERSION. Washington M.T.		IMMERSION. Angle f'm N.	EMERSION. Washington M.T.		EMERSION. Angle f'm N.	Duration	
			h	m	°	h	m	°	h	m
Sept. 4	116 B Scorpii	6.2	5	1	54	6	0	323	1	0
9	96 B Aquarii	6.5	15	9	356	15	35	302	0	26
15	ε Arietis	4.6	8	16	40	9	2	298	0	46
18	139 Tauri	4.7	16	45	19	17	13	344	0	28
21	d^1 Cancri	5.9	12	54	146	13	33	236	0	39
Oct. 5	o Capricorni	5.6	10	12	5	10	50	296	0	39
6	29 Capricorni	5.5	3	15	94	4	14	225	0	59
7	ρ Aquarii	5.3	9	56	82	11	1	204	1	4
7	170 B Aquarii	6.0	12	13	79	13	13	214	1	0
12	μ Arietis	5.7	10	23	127	10	54	177	0	32
13	66 Arietis	6.1	6	30	28	7	6	297	0	36
13	17 Tauri	3.8	15	28	27	16	20	312	0	52
13	23 Tauri	4.3	16	2	84	17	23	262	1	22
13	η Tauri	3.0	16	52	56	17	59	294	1	7
13	27 Tauri	3.7	17	45	76	18	54	278	1	9
13	28 Tauri	5.2	17	50	56	18	51	297	1	1
19	o^2 Cancri	5.7	14	17	85	15	25	314	1	8
19	o^1 Cancri	5.1	14	26	152	15	19	246	0	54

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5ʰ; Central Standard 6ʰ; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 Sept.-Oct.							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.8	5	17			10	15		
RT Sculptor.		31.5	—26	13	9.6—10.5	0	12.3	3	17;	19	1;	12	2;	27	10
UU Androm.		38.5	+30	24	10.7—11.9	1	11.7	6	0;	20	20;	13	4;	28	0
U Cephei	0	53.4	+81	20	7.0— 9.0	2	11.8	10	13;	25	12;	10	11;	25	10
Z Persei	2	33.7	+41	46	9.4—12	3	01.4	13	2;	25	8;	7	13;	25	21
TW Cassiop.		37.6	+65	19	8.2— 9.0	1	10.3	12	3;	26	9;	10	16;	24	23
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	6	4;	26	18;	10	11;	24	5
RZ Cassiop.		39.9	+69	13	6.9— 8.1	1	04.7	8	16;	23	1;	7	9;	21	17
TX Cassiop.		44.4	+62	22	9.4—10.1	2	22.2	8	22;	26	12;	5	6;	22	20
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	10	10;	26	8;	12	5;	28	2
RX Cassiop.	2	58.8	+67	11	8.6— 9.1	32	07.6			23	11			25	19
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	10	4;	21	15;	8	18;	25	23
RT Persei		16.7	+46	12	9.5—11.5	0	20.4	3	17;	17	7;	7	17;	21	7
λ Tauri		55.1	+12	12	3.3— 4.2	3	22.9	4	13;	20	8;	6	4;	21	23
RW Tauri	3	57.8	+27	51	7.1—<11	2	18.5	6	15;	23	6;	1	14;	18	4
RV Persei	4	04.2	+33	59	9.5—11.0	1	23.4	9	4;	24	23;	2	20;	18	15
RW Persei		13.3	+42	04	8.8—11.0	15	04.8	6	15;	19	19;	3	0;	29	10
SZ Tauri		31.4	+18	20	7.2— 7.7	3	03.6	9	22;	28	19;	8	6;	27	3
RS Cephei	4	48.6	+80	06	9.5—12.0	12	10.1	7	21;	20	7;	2	17;	27	14
TT Aurigae	5	02.8	+39	27	7.8— 8.7	0	16.0	4	15;	17	23;	7	23;	27	23
RY Aurigae		11.5	+38	13	10.7—11.7	2	17.5	10	5;	21	2;	7	11;	23	20
RZ Aurigae		42.9	+31	40	10.6—13.3	3	00.3	10	6;	22	7;	10	8;	28	10
SV Tauri		45.8	+28	05	9.4—11.0	2	04.0	3	6;	20	14;	7	22;	25	7
Z Orionis		50.2	+13	40	9.7—10.7	5	04.9	9	15;	30	10;	10	20;	31	16
SV Gemin.		54.6	+24	28	9.8—<11	4	00.2	7	18;	23	19;	9	19;	25	20
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	12	11;	23	22;	11	3;	22	14
U Columbae	6	11.2	—33	03	9.2—10.0	2	19.2	9	15;	20	19;	7	15;	24	10
SX Gemin.		22.0	+20	37	10.8—11.5	1	08.8	12	22;	29	8;	7	13;	23	22
RW Monoc.		29.3	+ 8	54	9.0—10.8	1	21.7	12	5;	27	11;	5	2;	27	23
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0	12	18;	24	23;	7	4;	31	14
RU Monoc.	6	49.4	— 7	28	9.8—10.5	0	21.5	7	0;	21	9;	12	21;	27	5
R Can. Maj.	7	14.9	—16	12	5.8— 6.4	1	03.3	12	15;	30	19;	9	21;	28	1
RY Gemin.		21.7	+15	52	8.9—<10	9	07.2	5	9;	24	0;	3	7;	21	21
Y Camelop.		27.6	+76	17	9.5—12	3	07.3	18	21;	28	19;	18	14;	28	13
TX Gemin.		30.3	+17	8	10.0—11.9	2	19.2	8	20;	25	15;	13	10;	30	5
RR Puppis		43.5	—41	08	9.4—10.7	6	10.3	4	5;	23	12;	12	19;	25	15
V Puppis	7	55.4	—48	58	4.1— 4.8	1	10.9	8	11;	23	0;	14	20;	29	9
X Carinae	8	29.1	—58	53	7.9— 8.7	0	13.0	3	23;	20	4;	6	10;	22	16
S Cancri	8	38.2	+19	24	8.2—10	9	11.6	10	10;	29	10;	8	21;	27	21
RX Hydrae	9	00.8	— 7	52	9.1—10.5	2	6.8	3	22;	22	5;	10	11;	28	17
S Velorum		29.4	—44	46	7.8— 9.3	5	22.4	7	23;	19	19;	7	15;	25	10
Y Leonis	9	31.1	+26	41	9.3—11.2	1	16.5	7	23;	24	19;	11	16;	28	13
RR Velorum	10	17.8	—41	36	10.0—10.9	1	20.5	6	1;	24	14;	3	20;	22	9
SS Carinae	10	54.2	—61	23	12.2—12.8	3	07.2	4	21;	18	2;	7	22;	27	17
ST Urs. Maj.	11	22.4	+45	44	6.7— 7.2	8	19.2	8	10;	26	0;	13	14;	31	5
RW Urs. Maj.		35.4	+52	34	10.3—11.4	7	07.9	5	14;	20	6;	12	5;	26	21
Z Draconis	11	39.8	+72	49	9.9—13.6	1	08.6	10	1;	23	15;	13	23;	27	13
RZ Centauri	12	55.6	—64	05	8.5— 8.9	1	21.0	9	21;	24	21;	9	21;	24	21
RS Can. Ven.	13	06.3	+36	28	7.5—12.5	4	19.2	6	1;	25	6;	4	20;	24	1
SS Centauri	13	07.2	—63	37	8.8—10.4	2	11.5	7	21;	22	18;	15	2;	29	22
δ Librae	14	55.6	— 8	07	4.8— 6.2	2	07.9	13	19;	27	18;	11	17;	25	16

Minima of Variable Stars of Short Period—Continued.

Star #	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 Sept -Oct.							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
U Coronae	15	14.1	+32	01	7.6— 8.7	3	10.9	11	13;	25	7;	9	2;	22	22
TW Draconis		32.4	+64	14	7.3— 8.9	2	19.4	13	20;	30	16;	9	2;	25	22
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	9	18;	25	1;	10	9;	25	16
SW Ophiuchi	16	11.1	− 6	44	9.2—10.0	2	10.7	6	12;	21	4;	5	20;	20	12
SX Ophiuchi		12.6	− 6	25	10.5—11.2	2	01.5	11	18;	28	6;	14	19;	31	7
R Arae		31.1	—56	48	6.8— 7.9	4	10.2	7	6;	24	23;	12	15;	30	8
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1	14	3;	25	4;	4	21;	25	15
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	7	10;	21	1;	11	11;	25	1
U Ophiuchi		11.5	+ 1	19	6.0— 6.7	0	20.1	7	17;	24	11;	11	6;	28	0
u Herculis		13.6	+33	12	4.6— 5.4	2	01.2	5	6;	23	17;	6	0;	18	7
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	8	19;	23	5;	7	15;	22	1
RV Ophiuchi		29.8	+ 7	19	9. —12	3	16.5	3	12;	18	6;	10	9;	25	3
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	6	3;	22	11;	8	20;	25	5
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	11	0;	26	2;	11	4;	26	6
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	10	2;	25	13;	11	1;	26	13
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	8	19;	24	18;	10	17;	26	17
WX Sagittae		53.6	—17	24	9.2—10.8	2	03.1	7	14;	24	15;	3	4;	20	5
WY Sagittae	17	54.9	—23	1	9.5—10.6	4	16.0	8	7;	27	0;	6	8;	25	0
SX Draconis	18	03.0	+ 58	23	9.3—10.5	5	04.1	5	22;	26	14;	6	22;	27	14
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	3	16;	18	4;	9	22;	24	9
V Serpentis		11.1	−15	34	9.5—11.1	3	10.9	8	23;	22	19;	13	12;	27	8
RZ Scuti		21.1	− 9	15	7.4— 8.3	15	03.2	15	8;	30	12;	15	15;	30	18
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	13	2;	29	15;	7	21;	24	10
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	13	14;	22	11;	10	6;	28	1
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	6	15;	23	5;	9	20;	26	11
RR Draconis		40.8	+62	34	9.3—13	2	19.9	13	10;	30	10;	8	21;	25	21
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	10	18;	24	1;	7	8;	27	6
β Lyrae		46.4	+33	15	3.4— 4.1	12	21.8	8	2;	21	0;	3	22;	29	17
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	8	2;	27	4;	6	18;	25	20
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	9	12;	24	15;	9	19;	24	22
RV Lyrae		12.5	+32	15	11. —12.8	3	14.4	14	12;	28	21;	13	7;	27	16
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	9	17;	27	15;	6	14;	24	12
U Sagittae		14.4	+19	26	6.5— 9.0	3	09.1	8	3;	22	16;	6	5;	26	11
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	8	21;	23	14;	8	8;	23	1
TT Lyrae		24.3	+41	30	9.3—11.6	5	05.8	10	10;	20	22;	6	15;	22	9
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	8	8;	21	9;	10	22;	23	23
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	7	15;	19	15;	7	15;	25	16
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	8	4;	28	2;	11	8;	24	15
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	9	23;	28	6;	16	13;	25	17
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	4	18;	21	15;	8	11;	25	8
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	8	20;	29	4;	12	18;	26	8
UW Cygni		19.6	+42	55	10.5—10.8	3	13	8	8;	22	3;	12	20;	26	15
V Vulpec.		32.3	+26	15	8.2—9.8	37	19.0			28	4				
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	8	10;	27	15;	7	6;	26	11
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	10	18;	29	4;	8	8;	26	17
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	4	10;	26	21;	11	21;	26	20
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	7	8;	19	1;	12	9;	24	2
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	8	14;	28	19;	8	21;	29	2
VV Cygni	21	02.3	+45	23	12.1—13.8	1	11.4	3	22;	18	16;	3	11;	25	14
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	5	12;	24	21;	4	14;	23	23
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	2	12;	26	3;	11	20;	27	14
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3			21	1			22	8
RT Lacertae	21	57.4	+43	24	9.1—10.5	5	01.7	1	14;	21	21;	2	1;	22	8
RW Lacertae	22	40.6	+49	08	10.2—11.2	5	04.4	8	0;	23	14;	9	3;	24	16
X Lacertae	22	45.0	+55	54	8.2— 8.6	5	10.6	6	16;	23	0;	9	8;	20	5
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.3	7	8;	23	22;	10	12;	27	2
Y Piscium		29.3	+ 7	22	9.0—12.0	3	18.4	8	19;	23	20;	8	22;	23	23
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	11	23;	28	11;	14	22;	31	10

Maxima of Variable Stars of Short Period.

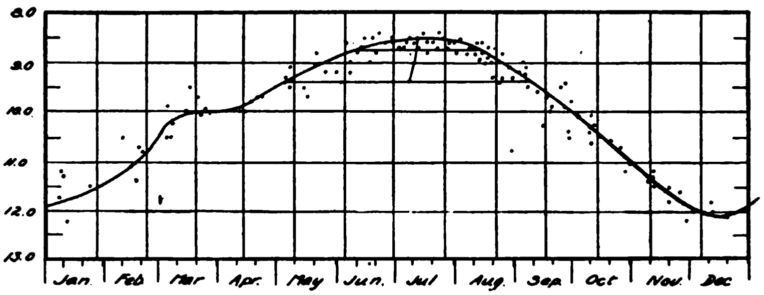
[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

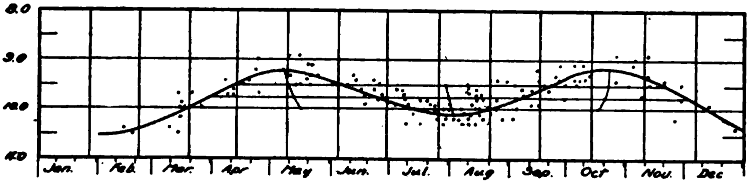
Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. Sept.-Oct.							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SX Cassiop.	0	05.5	+54	20	8.6— 9.4	36	13.7			24	0			29	13
SY Cassiop.	0	09.8	+57	52	9.3— 9.9	4	1.7	11	17;	27	23;	14	6;	30	13
RR Ceti	1	27.0	+ 0	50	8.3— 9.0	0	13.3	9	0;	24	12;	9	23;	25	11
RW Cassiop.	1	30.7	+57	15	8.9—11.0	14	19.2	10	17;	25	12;	10	7;	25	2
V Arietis	2	09.6	+11	46	8.3— 9.0	0	23.8	8	13;	24	10;	10	7;	26	4
SU Cassiop.	2	43.0	+68	28	6.5— 7.0	1	22.8	4	6;	19	20;	5	10;	21	0
TU Persei	3	01.8	+52	49	11.4—12.2	0	14.6	13	19;	28	9;	12	23;	27	12
RW Camelop.	3	46.2	+58	21	8.2— 9.4	16	00.0	14		30		16			
SX Persei	4	10.2	+41	27	10.4—11.2	4	07.0	7	13;	24	17;	11	21;	29	1
SV Persei		42.8	+42	07	8.8— 9.6	11	03.1	6	18;	29	0;	10	3;	21	6
RX Aurigae	4	54.5	+39	49	7.2— 8.1	11	15.0	10	12;	22	3;	3	18;	27	0
SX Aurigae	5	04.6	+42	02	8.0— 8.7	1	12.8	8	18;	24	2;	9	9;	24	17
SY Aurigae		05.5	+42	41	8.4— 9.5	10	03.3	10	19;	20	22;	11	5;	31	11
Y Aurigae		21.5	+42	21	8.6— 9.6	3	20.6	9	13;	24	23;	10	10;	25	20
RZ Gemin.	5	56.6	+22	15	9.1—10.0	5	12.7	8	19;	25	9;	11	22;	23	0
RS Orionis	6	16.5	+14	44	8.2— 8.9	7	13.6	12	16;	27	19;	12	22;	28	1
T Monoc.		19.8	+ 7	08	5.7— 6.8	27	00.3	6	20			3	20;	30	20
RZ Camelop.		23.7	+67	06	11.0—13.0	0	11.5	10	20;	25	6;	9	16;	24	2
W Gemin.		29.2	+15	24	6.7— 7.5	7	22.0	12	1;	27	21;	5	19;	21	15
ζ Gemin.	6	58.2	+20	43	3.7— 4.3	10	03.7	12	8;	22	12;	2	16;	22	23
RU Camelop.	7	10.9	+69	51	8.5— 9.8	12	06.5	9	10;			1	16;	23	22
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	14	12;	30	18;	8	18;	24	15
V Carinae	8	26.7	−59	47	7.4— 8.1	6	16.7	5	15;	19	0;	9	2;	22	12
T Velorum	8	34.4	−47	01	7.6— 8.5	4	15.3	11	17;	30	7;	9	13;	28	2
V Velorum	9	19.2	−55	32	7.5— 8.2	4	08.9	7	16;	25	4;	12	15;	30	3
Z Leonis	9	46.4	+27	22	7.9— 9.6	59	0.0			22					
RR Leonis	10	02.1	+24	29	9.1—10.1	0	10.9	8	1;	21	14;	11	23;	25	13
SU Draconis	11	32.2	+67	53	8.9— 9.6	0	15.8	10	1;	23	6;	6	11;	19	16
S Muscae	12	07.4	−69	36	6.4— 7.3	9	15.8	7	2;	26	10;	5	1;	24	9
SW Draconis		12.8	+70	04	8.8— 9.6	0	13.7	10	15;	26	4;	12	3;	28	2
T Crucis		15.9	−61	44	6.8— 7.6	6	17.6	13	13;	27	10;	10	21;	24	8
R Crucis		18.1	−61	04	6.8— 7.9	5	19.8	7	9;	24	20;	12	7;	23	23
S Crucis	12	48.4	−57	53	6.5— 7.6	4	16.6	7	10;	21	11;	10	5;	24	7
W Virginis	13	20.9	− 2	52	8.7—10.4	17	06.5	12	6;	29	13;	16	19		
SS Hydrae		25.0	−23	08	7.4— 8.1	8	4.8	11	0;	27	10;	13	19;	30	5
RV Urs. Maj.	13	29.4	+54	31	9.2— 9.9	0	11.2	12	3;	26	4;	10	5;	31	6
ST Virginis	14	22.5	− 0	27	10.3—11.4	0	09.9	8	13;	25	0;	11	10;	27	20
V Centauri		25.4	−56	27	6.4— 7.8	5	11.9	11	7;	22	7;	14	6;	25	6
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	11	8;	26	9;	11	11;	26	14
RU Bootis	14	41.5	+23	44	12.8—14.3	0	11.9	13	2;	27	22;	12	18;	27	14
R Triang. Austr.	15	10.8	−66	08	6.7— 7.4	3	09.3	8	16;	22	5;	5	18;	19	8
S Triang. Austr.	15	52.2	−63	29	6.4— 7.4	6	07.8	11	21;	24	13;	13	12;	26	3
S Normae	16	10.6	−57	39	6.6— 7.6	9	18.1	8	0;	27	12;	7	6;	26	19
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	3	6;	20	23;	8	16;	26	9
RV Scorpii	16	51.8	−33	27	6.7— 7.4	6	01.5	11	13;	23	16;	11	21;	24	0
X Sagittarii	17	41.3	−27	48	4.4— 5.0	7	00.3	13	5;	27	6;	11	6;	25	7
Y Ophiuchi		47.3	− 6	07	6.1— 6.5	17	02.9			17	21;	4	0;	21	3
W Sagittarii	17	58.6	−29	35	4.3— 5.1	7	14.3	7	11;	22	16;	15	10;	30	15
Y Sagittarii	18	15.5	−18	54	5.4— 6.2	5	18.6	8	17;	20	6;	7	13;	24	21
U Sagittarii		26.0	−19	12	6.5— 7.3	6	17.9	13	0;	26	11;	9	24;	23	11

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. Sept.-Oct.							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
Y Scuti	18	32.6	− 8	27	8.7— 9.2	10	08.3	11	6;	21	15;	1	23;	22	16
Y Lyrae		34.2	+43	52	11.3—12.3	0	12.1	9	23;	22	0;	10	3;	22	4
RZ Lyrae		39.9	+32	42	9.9—11.2	0	12.3	12	2;	24	9;	12	18;	25	1
RT Scuti		44.1	−10	30	9.1— 9.7	0	11.9	12	6;	24	4;	12	0;	23	21
κ Pavonis	18	46.6	—67	22	3.8— 5.2	9	02.2	4	15;	22	20;	11	0;	29	4
U Aquilae	19	24.0	− 7	15	6.2— 6.9	7	00.6	13	14;	27	14;	11	14;	25	17
XZ Cygni		30.4	+56	10	8.6— 9.3	0	11.2	13	5;	27	4;	11	4;	25	4
U Vulpec.		32.2	+20	07	6.5— 7.6	7	23.5	11	23;	27	22;	5	21;	21	20
SU Cygni		40.8	+29	01	6.2— 7.0	3	20.3	11	6;	24	15;	11	0;	26	8
η Aquilae		47.4	+ 0	45	3.7— 4.5	7	04.2	6	17;	21	2;	5	10;	19	19
S Sagittae		51.5	+16	22	5.6— 6.4	8	09.2	6	22;	23	16;	10	11;	27	5
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	9	11;	22	2;	11	1;	23	17
X Cygni	20	39.5	+35	14	6.0— 7.0	16	09.3	12	18;	29	3;	15	13;	31	22
T Vulpec.		47.2	+27	52	5.5— 6.1	4	10.5	12	18;	26	1;	9	8;	27	2
WY Cygni		52.3	+30	03	9.6—10.4	0	13.5	8	0;	21	10;	11	16;	25	2
RV Capric.		55.9	−15	37	9.2—10.1	0	10.7	13	15;	27	1;	10	11;	23	22
TX Cygni	20	56.4	+42	12	8.5— 9.7	14	17.4	15	1;	29	18;	14	12;	29	5
VY Cygni	21	00.4	+39	34	8.8— 9.5	7	20.6	10	23;	26	16;	12	9;	20	6
SW Aquarii		10.2	— 0	20	9.9—10.8	0	11.0	12	10;	26	15;	10	9;	24	4
VZ Cygni	21	47.7	+42	40	8.2— 9.2	4	20.7	6	5;	20	19;	10	6;	24	20
Y Lacertae	22	05.2	+50	33	9.1— 9.6	4	07.8	3	16;	21	0;	8	7;	25	13
δ Cephei		25.5	+57	54	3.7— 4.6	5	08.8	12	21;	23	15;	9	17;	25	19
Z Lacertae		36.9	+56	18	8.2— 9.0	10	21.1	1	10;	23	4;	4	1;	25	19
RR Lacertae		37.5	+55	55	8.5— 9.2	6	10.1	10	0;	22	21;	5	17;	24	23
V Lacertae	22	44.5	+55	48	8.5— 9.5	4	23.6	9	7;	24	6;	9	5;	24	4
SW Cassiop.	23	03.7	+58	11	9.2— 9.7	5	10.6	4	7;	20	14;	6	22;	23	6
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	9	23;	22	13;	11	11;	24	1
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4	11	21;	24	1;	6	4;	30	11
V Cephei	23	51.7	+82	38	6.0—7.0	0	23.6	9	3;	24	2;	9	1;	24	0



LIGHT CURVE for 1915 of 153378 S URSAE MINORIS
Maximum July 12; mag. 8.5
From observations by Amer Assn of Var. Star Observers.
Chas. B. Lindsley
Cin'ti, Ohio

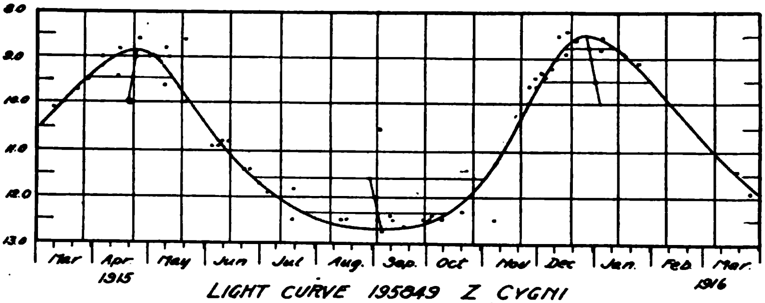


LIGHT CURVE FOR 1915 OF R URSAE MINORIS 163172

Max. May 7, (9.2); min Jul. 29, (10.1); max. Oct. 22 (9.2)

Observations by Amer. Assn of Var Star Observers.

Chas. B. Lindsley
Cinti., O

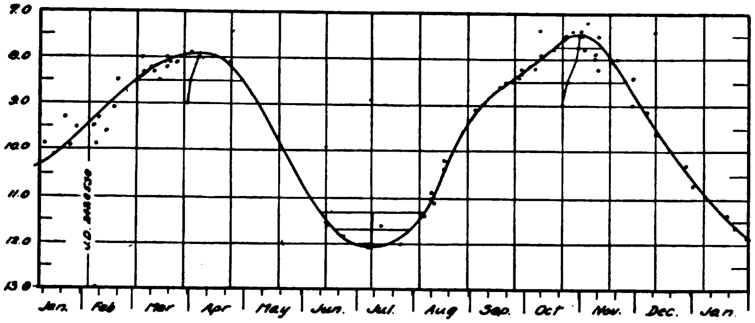


LIGHT CURVE 195849 Z CYGNI

Max. Apr. 23 (8.8); min Sept 5 (12.7), max Dec. 26 (8.5)

Observations by A. A of V. S. O.

Chas. B. Lindsley
Cinti., O.



LIGHT CURVE OF 230759 V CASSIOPEIAE FOR 1915

Max. 1, Apr. 5 (J.D. 2420593), mag. 7.9. Max. 2, Oct. 28 (J.D. 2420799); mag. 7.5.

Min. July 8 (J.D. 2420687); mag. 12.1

Observations by Amer. Assn. of Var Star Observers

C. B. Lindsley
Cinti., O.

COMET AND ASTEROID NOTES.

Comet 1916 *b* (Wolf).—The new comet which was announced in our last number is quite remarkable, in that it was discovered at almost the distance of Jupiter from the sun. It is in the opposite part of the sky from that now occupied by Jupiter, so that it is not subject to any sensible perturbations by that planet. The orbit is very uncertain yet, but it is probable that the elliptic orbit computed by Van Biesbroeck is not correct. The best elements which have come to hand are those given in the *Lick Observatory Bulletin* No. 282, computed by R. T. Crawford and Dinsmore Alter, which represent 13 observations from April 24 to May 30 with great accuracy. These elements are parabolic and indicate that the comet will reach perihelion about June 16, 1917. Professor E. E. Barnard found an image of the comet on a photograph taken April 24, three days before the discovery by Wolf.

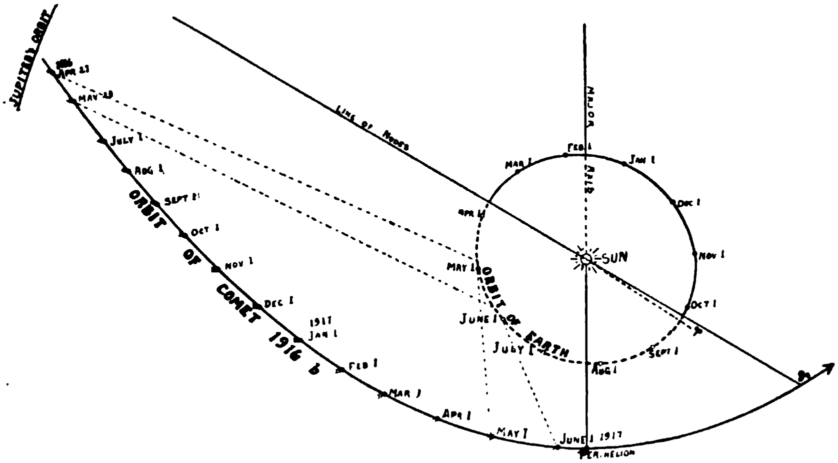
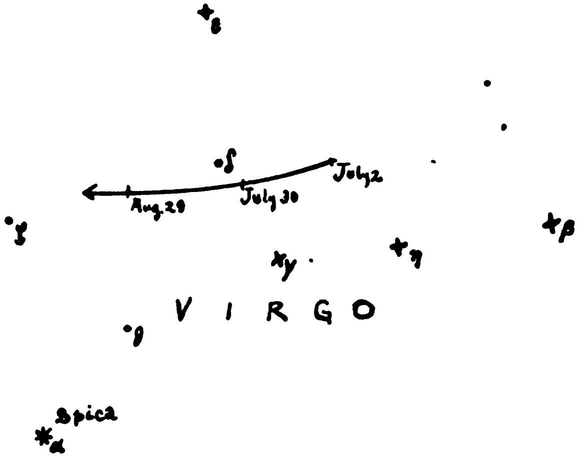


Diagram of the Orbit of Comet 1916 *b* (Wolf).

The accompanying diagram shows the relation of part of the comet's orbit to the orbits of the earth and Jupiter. It is evident that next summer when the comet reaches perihelion it will be much more favorably situated for observation than it is now and that it may become a conspicuous object.

Elements by Crawford and Alter.

$$T = 1917\ \text{June}\ 16.4806\ \text{Gr. M. T.}$$
$$\left.\begin{array}{l}\omega = 120^\circ\ 37'\ 07''.9\\ \Omega = 183\ \ 16\ \ 58\ .8\\ i = \ \ 25\ \ 40\ \ 06\ .4\end{array}\right\}\ 1916.0$$
$$\log q = 0.226855 \qquad q = 1.683$$



APPARENT COURSE OF COMET 1916 *b* AMONG THE STARS IN JULY AND AUGUST.

The following ephemeris for the month of August is given in the *L. O. Bulletin* 282.

Gr. M. T. 1916	True α	True δ	log Δ	Brightness
	h m s	° ′ ″		
Aug. 1.5	12 46 21.0	+3 33 21		
3.5	47 40.3	26 54		
5.5	49 02.2	20 15	0.6562	1.16
7.5	50 26.5	13 23		
9.5	51 53.3	3 06 19		
11.5	53 22.5	2 59 04		
13.5	54 54.0	51 37	0.6584	1.19
15.5	56 27.9	44 00		
17.6	58 04.1	36 12		
19.5	12 59 42.6	28 14		
21.5	13 01 23.3	20 07	0.6598	1.23
23.5	03 06.2	11 50		
25.5	04 51.4	2 03 24		
27.5	06 38.8	1 54 50		
29.5	13 08 28.4	+1 46 08	0.6602	1.27

The elements bear a slight resemblance to those of Wolf's periodic comet 1884 III, but Professor Crawford thinks that the two cannot be identical.

Comet 1889 V Brooks.—On July 6, 1889 a comet was discovered by Dr. Wm. R. Brooks of Geneva, New York. When first seen it was rather faint, but had a short tail. It did not seem to change much in appearance until the following month, when it threw off four fragments. Two of these soon disappeared but the other two followed the main comet for a while and then gradually drifted away from it. In three weeks the nearer companion ceased to recede. Elements of the orbit were computed and its period was found to be a little over seven years. The small inclination and direct motion, and its periodic time suggested that it might possibly belong to Jupiter's family of comets. This fact was soon established by the investigations of Chandler and Poor in this country, and Bauschinger in Germany. It was found that the orbit at aphelion approaches very close to that of Jupiter, and Dr. Chandler found that in March 1886 the comet's distance from the planet was slightly less than nine millions of miles. The comet returned in 1896 according to calculations, and was first seen by Javelle at Nice as a single comet, no companion being seen. It was observed for many weeks. In 1903 it returned again, and was first seen by Dr. Aitken at the Lick Observatory. The diameter of the nucleus was about 3′, and it was slightly fainter than 14th magnitude. The comet seems to be gradually diminishing in brightness. It returned in 1910, and the next perihelion passage is due to take place February 15, 1918. The comet will probably not return in 1925, as it will make another near approach to Jupiter during March 13-20, 1922. The nearest approach will take place on March 16 of that year, when the least distance between the two bodies will be only 0.136 of an astronomical unit. I have computed a search ephemeris for August 20 to September 5 and September 25 to October 11 this year. I have also computed the heliocentric coördinates of both Jupiter and the comet for March 16, 1922 the next date of nearest approach.

SEARCH EPHEMERIS FOR BROOKS' COMET 1889 V.

1916		α	δ	log *r*	log Δ
		h m s	° ′ ″		
Aug.	20	14 25 30	−17 58 51	0.60740	0.62735
"	24	14 28 4	−18 10 26	0,60578	0.63137
"	28	14 30 49	−18 22 48	0.60414	0.63582
Sept.	1	14 33 45	−18 35 54	0.60250	0.63978
"	5	14 36 50	−18 49 41	0.60082	0.64352

Bright moon during interval September 5 to September 25.

		α	δ	log *r*	log Δ
		h m s	° ′ ″		
Sept.	25	14 54 36	−20 6 38	0.59228	0.65898
"	29	14 58 34	−20 23 14	0.59054	0.66139
Oct.	3	15 2 40	−20 40 11	0.58876	0.66353
"	7	15 6 54	−20 57 19	0.58696	0.66542
"	11	15 11 13	−21 14 30	0.58518	0.66706

Heliocentric coördinates of Jupiter and Brooks' comet 1889 V at time of nearest approach, March 16, 1922.

	Jupiter		Comet
	° ′ ″		° ′ ″
λ =	192 28 35	λ =	192 58 12
β =	+ 1 18 27	β =	+ 0 34 26
log *r* =	0.73692	log *r* =	0.72760

$x' = -5.32630$	$x^\circ = -5.20410$
$y' = -1.17852$	$y^\circ = -1.19861$
$z' = +0.12451$	$z^\circ = +0.05349$

F. E. SEAGRAVE.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, May, June, July, 1916.

In spite of an inclement and unseasonable spring, by reason of our scattered observing stations we are able to submit a favorable report, and maintain a good average. Our success is largely due to the efforts of Mr. Bancroft who contributes to the report 634 observations, the result of two months work. Mr. Bancroft is deserving of great credit for this example of zeal and industry.

It is a pleasure to welcome to our ranks this month Mr. Henry R. Schulmaier, "Sc" of Berwick, Me. Mr. Schulmaier observes with a 5″ refractor. His name was proposed by the Rev. T. C. H. Bouton. Other new members are Mr. A. W. Gregory "Gr" of Morristown, N. Y., and Mr. S. W. Pickering, "Wpi", the son of Mr. David B Pickering, who contributes his first list this month, twenty-three good observations. Miss Fanny M. Ludeke, "Lu" of Shandon, Cal., although only possessed of a field glass for observing, is worthy of membership in the Association by reason of her contributions of observations of the brighter variables. Mr. H. L. Baldwin returns to the active list this month. Mr. Baldwin is now located in Denver. Colo.

The following list of calculated dates of maxima is cited from the "Companion to the Observatory."

July	3	042209	R Tauri	Aug.	6	*191019*	R Sagittarii
	5	*022813*	U Ceti		7	050953	R Aurigae
	10	143227	R Boötis		12	*162112*	V Ophiuchi
	14	094211	R Leonis		16	193449	R Cygni
	16	123307	R Virginis		18	181136	W Lyrae
	19	001838	R Andromedae		20	081112	R Cancri
	21	*022000*	R Ceti		26	054920	U Orionis
	26	230759	V Cassiopeiae		26	043274	X Camelop.
					29	205923	R Vulpeculae

Space forbids extended comment on the many interesting features of this report. The recent maxima of the variable 213843 SS Cygni were well observed by a large number of our observers, and the irregular variable 154428 R Cor. Bor., is under such close scrutiny that any variation of moment is sure to be well observed. 147 observations of this variable in 65 days are recorded. The rapid increase in brilliance of the variable 090425 W Cancri seems especially noteworthy. This star has a period of 385 days, and recently in 44 days increased in brightness 4.0 magnitudes, an increase of 39.8 times, truly a remarkable performance for a variable with a period of this length.

The thanks of the Association are due Messrs. Bancroft, Eaton, McAteer, and others who contribute valuable early morning observations. Mr. McAteer observed a number of the neglected variables in Scorpius.

A highly gratifying feature of our work is the increase in the number of variables observed. A year ago we were observing about 140 variables, now we are approaching 200 variables a month, and contributing valuable observations of many variables heretofore neglected.

Those who have the Hagen tracing of the variable 203226 V Vulpeculae please correct the orientation. The south point is uppermost. Every member should carefully check up his observations each month with the report; where observations

VARIABLE STAR OBSERVATIONS May, June, July, 1916.

001046
X Androm.

J.D. 242	Est	Obs.
1037.7	11.6	Ba
42.8	<11.4	V

001755
T Cassiop.

0997.7	8.2	Pi
97.9	8.5	M
1015.7	8.4	S
18.9	8.7	M
41.7	8.5	Sp
43.7	8.1	Ba

001726
T Androm.

1034.9	9.8	E
37.7	9.8	Ba
42.8	9.2	V

001838
R Androm.

1010.8	8.0	Pi
32.9	7.8	M
34.9	7.5	E
37.7	7.6	Ba
42.8	7.1	V

004047
U Cassiop.

1037.7	11.6	Ba
37.8	9.7	M
38.9	11.3	E

004132
RW Androm.

1035.9	<11.5	E
37.7	<12.0	Ba

004435
V Androm.

1034.9	<11.1	E
37.7	<12.2	Ba
39.9	11.3	E

004533
RR Androm.

1037.7	11.8	Ba
39.9	<11.2	E
41.8	11.6	E

004746
RV Cassiop.

0997.9	<11.5	M
1037.8	10.1	M

004958
W Cassiop.

0982	9.5	L
97.9	9.6	M
1010.7	9.2	Ba
35.7	8.9	Ba
37.8	9.2	M

010940
U Androm.

J.D. 242	Est.	Obs.
1037.7	<12.0	Ba

013338
Y Androm.

1037.7	10.4	Ba

014958
X Cassiop.

0997.7	11.3	Pi
1032.9	10.5	M
43.7	11.0	Ba

015254
U Persei

1043.7	11.0	Ba

021558
S Persei

1043.7	8.8	Ba

023133
R Triang.

1035.9	10.3	E

024356
W Persei

0982	10.2	L
1043.7	8.9	Ba

025867
RX Cassiop.

0957	9.0	L

033362
U Camelop.

1005.6	7.5	Ba
45.7	7.8	Ba

043065
T Camelop.

1002.6	8.5	M
05.6	8.3	Ba
20.7	8.7	M

043274
X Camelop.

0957	8.7	L
80.7	10.5	R
86	10.6	L
87.6	10.9	V
93.6	11.3	Cr
93.6	11.1	Ba
96.6	11.4	Cr
1002.6	11.3	M
03.6	12.0	Ba
03.6	11.8	Cr
07.6	<11.1	V
08.6	11.5	M
10.6	11.9	Cr
10.6	12.2	Ba
11.6	11.6	M
18.6	<11.7	V
36.7	11.9	Pi

045514
R Leporis

J.D. 242	Est.	Obs.
0956	9.8	L
57	9.8	L

050953
R Aurigae

0993.6	9.0	M
97.5	8.6	Ba

052034
S Aurigae

0956	9.5	L
85.6	8.5	M

054920
U Orionis

0981.7	9.2	R
96	7.0	L

054974
V Camelop.

0993.6	<12.5	Ba
97.5	<12.5	Ba
1003.6	<13.3	Ba
05.6	13.1	Ba
07.6	<11.9	V
10.6	13.0	Ba
15.6	13.1	Ba
18.6	<11.3	V
27.6	<12.5	Ba

055353
Z Aurigae

0993.6	10.3	M
93.6	10.5	Ba

060450
X Aurigae

0956	11.2	L
81.7	9.2	R
92	8.9	L
93.6	8.3	N
93.6	8.5	Ba
95.6	8.4	Ba
1003.6	8.3	Ba
08.6	8.5	V
10.6	8.1	Ba

060547
SS Aurigae

0981.7	<10.8	R
87.6	<10.8	V
89.6	<12.8	B
90.6	<12.7	B
93.6	<12.4	Ba
93.6	<10.8	M
95.6	<12.0	Ba
96.6	<12.4	B
1003.6	<12.5	Ba
03.6	<13.3	B
05.6	11.7	Ba
08.6	<10.8	V
10.6	12.8	Ba

061647
V Aurigae

J.D. 242	Est.	Obs.
0993.6	<11.4	M

063159
U Lyncis

1005	<13.6	Ba

064030
X Gemin.

0989.6	11.4	V
93.6	10.8	Ba
97.6	10.7	Ba

065208
X Monoc.

0960	8.0	L
72	7.5	L
80	7.5	L
86	7.4	L

065355
R Lyncis

1005.6	9.6	Ba

070122
TW Gemin.

1009.7	8.3	R

070122
R Gemin.

0990.6	<12.5	B

070310
R Can. Min.

0950	10.0	L
80	9.0	L
81.7	9.1	R
92	9.0	L
96.6	8.6	B

071713
V Gemin.

0989.6	9.7	V
1010.6	8.4	Pi

072708
S Can. Min.

0956	10.8	L
80	11.5	L
81.6	<10.1	R

073508
U Can. Min.

0956	9.6	L
80	9.7	L
81.7	10.2	R
85.6	9.7	Bu
92	10.2	L
96.6	10.1	B

073723
S Gemin.

J.D. 242	Est.	Obs.
0988.6	10.6	Cr
1003.6	9.8	Cr
05.6	9.4	Cr
10.6	9.9	Cr
10.6	9.6	Pi

074922
U Gemin.

0985.6	<10.0	O
85.6	<11.4	M
88.6	<12.4	Cr
89.6	<11.7	V
90.6	<12.7	B
93.6	<12.5	Ba
93.6	<10.9	O
97.6	<12.5	Ba
1002.6	<10.9	M
02.6	<10.0	O
03.6	<13.5	B
03.6	<13.0	Ba
04.6	<12.3	Ba
05.6	<12.4	Cr
05.6	<12.5	Ba
08.6	<11.4	M
10.6	<12.8	B
10.6	<11.7	Pi
10.6	<12.7	Ba

081112
R Cancri

0956	8.6	L
85.6	8.3	Bu
96	7.3	L
97.6	7.3	Ba
1003.6	7.4	Ba

081617
V Cancri

0985.6	10.2	Bu
93.6	10.9	Ba
1005.6	11.0	Ba

082405
RT Hydrae

0974	8.1	L
85.6	7.8	Bu

083019
U Cancri

1015.6	<12.6	B

083350
X Urs. Maj.

1010.6	10.5	Ba

085120
T Cancri

0956	10.2	L
85.6	9.6	Bu
1002	10.5	L
05.6	9.8	Ba

VARIABLE STAR OBSERVATIONS May, June, July, 1916—Continued.

090151
V Urs. Maj.

J.D.	Est.	Obs.
242		
0954	10.3	L
72.3	10.0	L
74.3	10.3	L
80.3	10.3	L
80.7	10.1	R
81.7	10.2	R
82.3	10.2	L
82.6	10.2	L
85.6	9.8	M
85.7	9.5	Mu
89.6	10.3	V
91.7	9.6	Mu
93.6	10.2	Ba
96.3	10.4	L
1002.4	10.5	L
03.6	10.3	Ba
04.7	9.7	Mu
06.7	10.1	R
07.6	10.6	V
08.7	9.9	Mu
09.7	10.4	R
10.6	10.4	Ba
10.6	10.4	B
10.7	10.5	R
11.7	10.6	M
11.7	10.2	Mu
11.7	10.3	G
13.7	10.6	R
14.7	10.3	R
16.6	10.4	Ba
18.6	10.9	V
18.7	10.6	R
19.7	10.7	R
20.7	10.9	R
21.7	10.2	Mu
27.6	10.5	Ba
31.7	10.3	Mu
32.7	10.6	Mu
32.7	11.0	Pi
33.7	10.8	R
35.7	10.5	Mu
40.7	10.5	R
41.7	10.5	R
43.6	10.4	Ba

090425
W Cancri

0993.6	11.6	Ba
1003.6	11.1	Ba
07.7	10.2	V
10.6	10.0	Ba
15.6	8.9	B
16.6	9.0	Ba
16.6	8.9	S
18.7	8.5	M
33.6	7.5	Ba
37.6	7.5	Ba

093014
X Hydrae

J. D.	Est.	Obs.
242		
0985.6	10.0	Bu

093934
R Leo. Min.

0985.6	9.2	Bu
85.7	10.0	M
92.7	9.2	R
93.6	9.3	Ba
1002.6	9.6	Hu
05.6	9.4	Ba
09.6	9.6	S
10.6	10.0	Pi
18.6	10.2	M
18.7	10.5	R
32.7	10.6	R
33.6	10.1	Ba
35.6	<10.0	S
36.6	<10.8	Wpi
36.6	10.8	Pi

094211
R Leonis

0972	9.6	L
85.6	9.6	Bu
85.7	9.4	Mu
85.7	9.7	M
90.6	9.0	Sc
90.6	8.8	B
91.7	9.5	Mu
92.7	9.3	E
92.7	10.4	R
93.6	9.1	Ba
93.6	8.8	B
1002	9.5	L
04.7	9.5	Mu
05. 6	9.0	Ba
08	8.9	Wh
09.6	9.2	S
08.7	9.6	Mu
10.6	9.2	Pi
11.7	9.0	Bl
11.7	9.5	Mu
11.7	9.4	G
14.7	9.8	R
16	8.9	Υ
18.6	8.9	M
19	8.8	Υ
27.6	9.0	Ba
32.7	9.8	R
33	8.9	Wh
36.6	8.8	Wpi
36.6	8.8	Pi
37.6	8.2	Ba
37.6	9.0	S

094622
Y Hydrae

0985.6	6.8	Bu

095421
V Leonis

J.D.	Est.	Obs.
242		
0985.7	<11.3	M
1018.7	<11.5	M
37.6	<12.6	Ba

103212
U Hydrae

0974	5.0	L
0978.7	5.7	G
1009.7	5.3	R

103769
R Urs. Maj.

0993.6	12.1	Ba
97.6	12.2	Ba
1003.6	12.3	Ba
10.6	12.6	Ba
10.7	<12.0	Pi
14.7	12.4	M
16.6	12.5	Ba
28.7	<11.0	M
32.6	12.8	Ba
37.6	12.5	Ba
41.6	11.7	M
44.6	12.5	Ba

104620
V Hydrae

0974	6.2	L
85.6	6.3	Bu
1009.7	7.5	R

104814
W Leonis

1019.6	<11.2	V
37.6	<12.9	Ba

110506
S Leonis

1015.7	9.5	M

115919
R Comae

1002.6	10.8	O
03.6	10.5	Ba
03.6	10.8	B
09.6	10.2	O
10.6	10.0	Pi
10.6	10.2	Ba
11.6	10.5	M
15.6	9.8	O
15.7	9.5	Pi
16.6	9.6	Ba
17.6	9.5	O
18.7	9.2	M
20.7	9.5	R
27.6	9.0	Ba
28.7	9.1	M
35.6	8.8	B
36.6	8.8	Pi
36.6	9.3	Wpi
37.6	8.6	Ba

R Comae

J.D.	Est.	Obs.
242		
1037.6	8.8	O
37.6	8.8	B
38.6	8.8	B
41.6	8.9	B
43.6	8.4	Ba
44.6	8.7	B
45.6	8.7	O

120012
SU Virginis

0985.6	9.2	Bu
89.7	9.5	V
91.6	9.6	Ba
93.6	9.3	B
1003.6	10.6	Ba
03.7	10.0	M
07.7	10.7	V
10.6	10.8	Ba
16.6	11.3	Ba
18.6	11.5	V
28.7	11.4	M
33.6	12.4	Ba
35.6	12.2	B
41.6	12.4	Ba

120905
T Virginis

0989.7	10.9	V
93.6	10.6	B
1003.7	<10.6	M
05.6	11.6	Ba
16.6	11.9	Ba
35.6	12.8	B

121418
R Corvi

0985.6	7.6	Bu
88.6	7.9	Ma
91.6	7.9	Ba
93.6	7.8	B
93.6	8.2	M
1003.6	8.1	Ba
05.6	8.5	O
09.7	8.7	R
10.6	8.5	Pi
10.6	8.6	Ba
15.6	8.5	O
15.6	8.8	Ba
15	9.1	Nt
18.7	9.0	M
19.6	9.0	O
32.7	10.1	R
44.6	10.0	B

122001
SS Virginis

0985.6	8.3	Bu
91.6	8.1	Ba

SS Virginis

J.D.	Est.	Obs.
242		
1003.6	8.2	Ba
03.6	8.0	B
03.7	9.5	M
04.6	8.5	Hu
10.6	8.3	Ba
16.6	8.3	Ba
20.7	9.1	M
27.6	8.2	Ba
37.6	8.2	Ba
44	9.2	Nt
45.6	8.1	Ba

122532
T Can. Ven.

0985.6	9.7	Bu
85.6	9.8	M
91.6	9.5	Ba
1003.6	9.4	Ba
10.6	9.4	Ba
16	8.9	Υ
16.6	9.5	Ba
20.7	9.5	M
27.6	9.5	Ba
35.6	9.6	Ba
35	9.0	Υ
36.6	10.3	WPi
36.6	9.9	Pi
43.6	9.7	Ba

122803
Y Virginis

1016.6	<13.0	Ba
20.7	<11.1	M
37.6	13.1	B
37.6	12.5	Ba

123160
T Urs. Maj.

0985.6	8.4	Bu
85.6	8.6	O
85.6	8.4	M
85.7	8.4	Mu
88.6	8.1	Ma
91.6	7.9	Ba
91.7	7.9	Mu
91.8	8.0	M
92.7	8.2	E
92.7	8.1	R
93.6	8.1	O
97.6	7.7	Ba
1003.6	7.7	Ba
03.7	8.2	M
07.6	7.8	Ma
09.7	8.2	S
10.6	7.7	Ba
10.7	7.6	Sp
10.7	7.6	R
10.7	8.1	Pi
12.7	8.1	M
15.6	7.3	Hu

VARIABLE STAR OBSERVATIONS May, June, July, 1916—Continued.

T Urs. Maj.

J.D.	Est.	Obs.
242		
16.6	7.8	Ba
16.6	8.1	Pi
17.6	8.2	O
20.7	8.2	M
25.7	7.8	R
27.7	8.1	M
28.6	7.7	Ba
31.6	7.9	M
32.6	7.9	Ba
35.6	8.1	S
36.6	7.8	Ma
37.6	8.0	Ba
37.6	8.3	O
37.6	7.9	Hu
41	8.1	Nt
41.6	7.8	M
42.6	8.3	Pi
42.6	8.6	Wpi
42.6	8.1	Ma
43.6	7.9	Ba
43.6	8.3	O
44.7	8.0	Sp
45	8.4	ϒ
46.6	8.3	O
51.6	8.6	O

123307
R Virginis

0974	10.1	L
85.6	9.0	O
85.6	9.2	Bu
90.7	8.1	Ba
90.7	8.6	O
92.7	8.4	E
92.7	8.1	R
93.6	8.2	O
93.6	8.0	B
1002.6	7.9	Pi
02.6	8.1	Wpi
03.6	7.9	Ba
03.7	7.8	M
04.6	7.9	Hu
09.6	7.8	O
09.6	7.9	S
09.6	7.6	Ma
10.6	7.7	Ba
10.7	7.3	R
15.6	7.1	O
16.6	7.2	Ma
16.6	7.7	Ba
20.7	7.6	M
27.6	7.6	Ba
32.7	7.0	R
35.6	7.5	Ba
43.6	7.5	Ma
43.6	7.5	Ba

123459
RS Urs. Maj.

J D.	Est.	Obs.
242		
0985.6	<11.8	M
1003.6	<13.0	Ba
12.7	<11.3	M
14.7	13.5	M
16.6	<13.0	Ba
20.7	<11.8	M
27.6	<12.4	Ba
32.6	13.4	Ba
37.6	13.4	Ba
41.6	13.3	Ba
42.6	<10.6	Wpi
42.6	<10.6	Pi

123961
S Urs. Maj.

0985.6	11.3	M
85.7	10.2	Mu
91.6	11.5	Ba
91.7	10.3	Mu
97.6	11.8	Ba
03.6	11.9	Ba
10.6	11.7	Ba
10.7	12.0	Sp
14.7	12.3	M
15.6	10.1	Hu
16.6	11.4	Ba
20.7	11.2	M
27.6	10.5	Ba
28.7	10.3	M
31.6	9.9	M
32.6	10.1	Ba
35.6	10.4	S
37.6	9.8	Ba
37.6	10.0	O
37.6	9.6	Hu
41	10.0	Nt
41.6	9.0	M
41.6	9.3	B
41.6	9.1	Ba
42.6	9.5	Pi
42.6	9.5	Ma
43.6	9.4	O
44.7	9.0	Sp
46.6	9.2	O
51.6	9.0	O

124204
RU Virginis

1016.6	13.0	Ba
32.6	13.5	Ba
32.7	10.9	R
37.6	13.3	Ba

124606
U Virginis

0986.6	8.5	Bu
91.6	8.5	Ba
92.7	8.7	E
93.6	8.7	O
1003.6	8.9	B

U Virginis

J.D.	Est.	Obs.
242		
03.6	8.9	Ba
03.7	9.1	M
09.6	9.1	O
09.7	9.3	S
10.6	9.2	Ba
15.6	9.2	Hu
16.6	9.4	Ba
17.6	9.4	O
20.7	9.6	M
33.6	10.5	Ba
41.6	11.8	B
43.6	11.4	Ba

132002
W Virginis

1015.8	9.5	M
20.7	9.4	M

132202
V Virginis

0991.6	8.9	Ba
93.6	8.9	B
1003.6	9.1	Ba
12.7	9.5	M
15.8	9.8	M
16.6	9.5	Ba
20.7	9.6	M
37.6	10.2	Ba
41.6	10.8	B

132422
R Hydrae

0974	6.9	L
82	6.4	L
1004.7	6.2	Mu
07.6	5.5	Ma
10.7	5.1	R
16.6	5.6	Ma
33.7	5.5	R

132706
S Virginis

0974	11.0	L
91.6	11.4	Ba
1003.6	11.9	Ba
04.7	11.6	M
10.7	<11.6	Pi
16.6	12.1	Ba
37.6	12.5	Ba
41.7	<10.0	M
44	<12.0	Nt

133273
T Urs. Min.

1010.6	12.1	Ba
16.6	12.0	Ba
19	10.0	ϒ
27.6	11.7	Ba
33.6	11.3	Ba
36.6	10.9	V
43.6	10.3	Ba

133658
V Urs. Min.

J.D.	Est.	Obs.
242		
01.9	8.2	ϒ
33	8.4	ϒ
37	8.2	ϒ

134440
R Can. Ven.

0985.6	10.4	M
86.6	9.8	Bu
91.6	10.3	Ba
92.7	10.7	R
1003.6	10.4	Ba
10.7	10.7	Ba
15.6	11.0	Hu
15.7	12.0	S
16.6	10.8	Ba
16.7	10.5	Sp
19.7	<10.5	R
20.7	10.8	M
27.6	11.0	Ba
35.6	11.4	Ba
36.6	11.2	Wpi
36.6	11.2	Pi
37.6	12.0	S
41.6	11.6	B
45.6	11.2	Ba

135908
RR Virginis

1005.6	12.9	Ba
41.6	12.0	M

140113
Z Bootis

1016.6	<13.5	Ba
37.6	<13.6	Ba

141567
U Urs. Min.

0986.6	<10.7	Bu
91.6	10.8	Ba
1003.6	11.2	Ba
10.7	11.2	Ba
10.7	11.6	Pi
16.6	11.2	Ba
16.6	11.4	Pi
17.6	11.9	B
27.6	11.5	Ba
35.6	12.0	Ba
41.6	12.0	B
43.6	12.0	Ba

141954
S Bootis

0986.6	10.6	Bu
91.6	10.4	Ba
1002.6	10.5	Wpi
02.6	10.4	Pi
03.7	10.5	Ba
03.8	10.7	M
10.7	10.2	Ba
11.7	10.5	Bl

S Bootis

J.D.	Est.	Obs.
242		
15.7	9.9	S
16.6	10.0	Ba
18.7	10.2	R
21.6	9.5	Sc
27.6	9.3	Ba
32.6	8.5	Wpi
32.6	8.7	Pi
32.8	8.7	M
33.7	8.3	R
35.6	8.7	Ba
43.6	8.5	Ba

141942
RX Bootis

01.6.	7.8	ϒ

142205
RS Virginis

0993.6	9.5	Ba
1003.6	8.2	Ba
10.6	8.2	B
10.7	8.2	Pi
15.8	8.3	M
16.6	7.9	Ba
33.6	7.9	Ba
43.6	8.4	Ba

142539
V Bootis

0954	9.7	L
84.7	10.6	Mu
86.6	9.6	Bu
86	9.2	L
91.7	8.9	Ba
91.7	9.4	Mu
93.6	9.3	O
95.5	9.0	Pi
96.6	8.8	B
1001.6	8.7	M
02.6	8.8	Wpi
02.6	9.2	O
02.6	8.8	Pi
03.6	8.8	Ba
04.7	9.2	Mu
07.6	8.5	Ma
09.6	8.5	Hu
10.7	9.0	R
11.7	8.5	Bl
11.7	8.6	G
15.6	8.3	Ba
15.7	8.8	S
19.6	8.2	Ba
27.6	8.0	Ba
32.6	8.0	Pi
32.6	8.1	Wpi
32.8	7.8	M
35.6	7.8	Ba
42.6	7.8	Pi
42.6	8.0	Wpi
42.7	7.5	Ma
43.6	7.7	Ba

VARIABLE STAR OBSERVATIONS May, June, July, 1916—Continued.

142584
R Camelop.

J.D.	Est.	Obs.
242		
0957	9.0	L
91.7	8.3	Ba
93.6	8.1	O
95.6	8.1	O
1002	8.2	Wh
02.6	8.1	O
03.6	8.0	Ba
05.6	8.2	Cr
09.6	8.1	O
10.7	8.2	B
10.7	8.2	Sp
10.7	8.4	R
13.6	8.1	O
15.6	8.0	Ba
15.6	8.0	Hu
15.7	8.2	Sp
17.6	8.1	O
19	8.0	ϒ
19.6	8.2	Ba
27.6	8.1	Ba
33	8.4	Wh
37.6	8.4	Ba
37.6	8.2	O
37.6	8.0	Hu
37.7	8.9	M
37	8.2	ϒ
41.7	8.3	Sp
43.6	8.4	O
45.6	8.5	Ba

143227
R Bootis

0974	10.9	L
86.6	9.9	Bu
91.7	9.5	Ba
93	9.2	O
95.6	9.3	O
96	9.0	L
1001.6	8.8	M
02.6	8.8	Wpi
02.6	9.1	O
02.6	9.0	Pi
03.6	8.9	Ba
1009.6	8.2	O
09.6	8.3	S
11.7	8.5	Bl
15.6	8.1	Ba
17.6	7.8	O
19.6	7.8	Ba
19.7	8.4	R
21.6	7.0	Sc
27.6	7.2	Ba
32.6	7.8	Wpi
32.6	7.4	Pi
32.8	7.6	M
35.6	7.0	Ba
37.6	7.1	O
43.6	6.9	Ba
44.7	7.4	Ma

144918
U Bootis

J.D.	Est.	Obs.
242		
0986.6	<10.5	Bu
89.7	10.8	V
91.7	11.2	Ba
1003.6	11.5	Ba
08.6	11.4	B
12.8	11.5	M
15.6	11.3	Ba
19.6	11.5	Ba
35.6	11.5	Ba
35.6	11.5	B
45.6	11.4	Ba

150018
RT Librae

0993.6	<13.0	Ba
1033.6	13.5	Ba
42.6	11.4	M

150519
T Librae

0993.6	<12.5	Ba
1033.6	13.3	Ba
42.6	11.2	M

150605
Y Librae

0968	12.0	L
0993.6	12.9	Ba
1015.7	12.0	Pi
35.6	<13.0	Ba
41.6	11.4	M

151520
S Librae

0993.6	12.4	Ba
1015.7	11.0	Pi
16.6	11.0	Ba
33.6	9.8	Ba
33.7	10.1	R
42.6	9.6	M
43.6	9.6	Ba

151714
S Serpentis

0993.6	<11.5	M
93.6	11.7	Ba
1003.6	11.7	Ba
07.7	11.4	V
15.6	11.2	Ba
16	10.5	ϒ
18.7	11.4	V
19.6	11.1	Ba
33.6	11.0	Ba
34.7	10.6	M
36.6	10.7	V
43.6	10.4	Ba

151731
S Cor. Bor.

J.D.	Est.	Obs.
242		
0986.6	10.2	Bu
90.6	9.6	B
93.6	10.0	O
93.6	9.1	Ba
1003.7	10.0	Ba
04.6	10.2	Hu
08.6	10.6	Pi
10.6	9.9	B
11.6	10.7	M
11.7	10.5	Bl
11.7	10.5	Mu
11.7	10.5	G
15.6	10.4	Ba
19.6	10.9	Ba
19.7	10.4	Mu
19.7	10.3	R
21.7	10.4	Mu
33.6	11.3	Ba
42.7	11.9	M
43.6	12.1	Ba
44.7	12.1	Sp

151822
RS Librae

0968	8.9	L
1003.6	8.2	Ba
15.6	8.6	Ba
15.7	9.2	Pi
16.6	8.3	B
19.6	8.5	Ba
33.6	9.8	Ba
42.6	9.8	M
45.6	10.4	Ba

152714
RU Librae

0954	10.9	L
93.6	8.3	Ba
1003.7	8.3	Ba
10.7	8.2	R
11.7	8.5	M
15.6	8.4	O
15.6	8.5	Ba
15.7	8.2	Pi
16.6	8.1	B
19.6	8.5	Ba
25.7	8.6	R
33.6	8.8	Ba
42.6	9.4	M
43.6	9.3	Ba

153215
W Librae

1042.6	10.3	M

153378
S Urs. Min.

J.D.	Est.	Obs.
242		
0985.7	8.5	Mu
86.6	8.6	Bu
86	8.7	L
91.7	8.5	Ba
91.7	8.4	Mu
1003.7	8.4	Ba
04.7	8.4	Mu
08.7	8.8	M
08.7	8.5	Mu
10.7	8.8	R
10.7	9.2	Pi
11.7	8.5	G
11.7	8.8	Bl
11.7	8.4	Mu
15	9.6	Nt
15.6	8.4	Hu
15.6	8.7	Ba
17.6	8.6	B
19.6	8.5	Ba
19.7	8.6	Mu
21.7	8.7	Mu
25.7	7.7	R
27.6	8.7	Ba
28.7	9.0	M
31.7	8.7	Mu
32.7	8.7	Mu
33	8.8	ϒ
35.6	8.9	Ba
35.7	8.7	Mu
35	9.0	ϒ
43.6	9.6	Pi
45.6	8.9	Ba

154428
R Cor. Bor.

J.D.	Est.	Obs.
0954	6.1	L
68	6.0	L
74	6.0	L
81.7	5.7	R
82	6.0	L
82.8	5.8	R
84.7	6.0	Lu
85.6	6.0	Cr
85.7	5.9	Lu
85.7	6.0	Mu
86.6	5.9	Bu
86.7	5.8	Lu
86	6.0	L
87.7	6.0	Bl
87.8	6.0	E
87.8	6.1	Mu
88.5	5.9	Nt
88.6	6.1	Ma
88.6	6.1	Cr
88.7	6.2	Mu
88.8	5.9	Lu
89.7	6.0	Bl
89.7	6.1	V
89.8	5.5	R

R Cor. Bor.

J.D.	Est.	Obs.
242		
0991.7	5.9	Mu
91.7	6.0	Lu
91.7	6.1	Ma
91.7	6.0	Ba
92.7	5.8	R
92.7	6.0	Mu
93.5	5.9	Nt
93.6	6.0	O
93.6	5.9	Ba
93.8	6.2	Lu
94.7	6.1	Mu
94.7	6.0	Lu
95.6	5.8	Ba
95.6	6.0	O
95.7	6.2	G
96.6	6.0	Cr
96	6.0	L
97.7	5.9	Lu
98.8	6.0	Lu
1000.7	5.9	Lu
1002	6.0	Wh
02.6	6.0	O
02.6	5.8	M
02.9	6.0	Lu
03.6	5.8	Ba
03.8	6.1	Mu
04.6	5.5	Hu
04.6	6.0	O
04.6	5.8	Ba
04.7	6.0	Mu
04.7	6.1	Lu
05.6	6.0	O
05.6	5.8	Ba
05.7	6.0	Bl
05.7	6.0	Lu
06.7	5.6	R
06.8	6.1	Mu
07.6	6.2	Ma
07.7	6.4	V
07.7	6.0	G
08.6	6.0	Pi
08.7	6.0	Mu
08.7	6.1	Lu
09.6	<6.0	S
09.6	6.0	O
09.7	5.5	R
09.8	6.1	Mu
10.6	6.0	Ba
10.7	5.8	R
10.8	6.1	Mu
11.7	6.0	Bl
11.7	6.1	Mu
11.7	6.1	G
13.6	6.0	O
13.7	5.7	R
14.7	6.0	Bl
14.7	5.7	R
14.7	6.0	Mu
15	5.9	Nt

Variable Star Observations May, June, July, 1916—Continued.

R Cor. Cor.

J.D.	Est.	Obs.
242		
1015.6	5.9	Sc
15.6	6.0	Ba
15.6	6.0	O
15.8	6.0	M
16.6	6.0	O
16.6	6.2	Ma
16.6	6.0	Ba
16.8	6.1	Mu
17.6	6.0	O
17.8	6.1	Mu
18.7	5.6	R
19.6	6.0	O
19.6	6.0	Cr
19.6	6.1	V
19.6	6.0	Ba
19.6	5.9	Hu
19.7	5.9	Mu
19.7	5.7	R
20.7	6.0	Mu
20.7	5.5	R
21.7	5.9	Mu
23.8	6.1	Mu
24.8	6.1	Mu
27.6	6.0	Ba
28.6	6.1	Ba
31.6	6.0	M
31.7	6.0	Mu
32.5	6.1	Ba
32.6	6.2	Wpi
32.7	6.0	Mu
32.7	5.8	R
33.6	6.1	Ba
33.6	6.5	Sc
33.7	5.9	R
33.8	6.1	Mu
34.7	6.0	Mu
35.6	6.1	Ba
35.7	6.1	Mu
35.8	6.2	E
36.6	6.0	Ma
36.6	6.0	Pi
36.7	6.5	V
36.7	6.0	Mu
37.6	6.0	O
37.6	6.1	Ba
37.8	6.3	Mu
38.7	6.1	Mu
38.8	6.0	E
39.7	6.2	Mu
39.8	6.1	E
40.6	6.1	Ma
40.7	5.6	R
41.6	5.9	Ba
41.6	6.5	Sc
41.7	5.8	R
41.8	6.0	E
42.6	6.0	Pi
42.7	6.0	M
43.6	6.0	O

R Cor. Bor.

J.D.	Est.	Obs.
242		
1043.6	5.9	Ba
44	6.3	Gr
44.6	5.8	Ba
45	6.0	Gr
45.6	5.8	Ba
45.6	6.0	O
45.6	6.0	Cr
45.6	6.0	O
51.6	6.0	O

154536
X Cor. Bor.

J.D.	Est.	Obs.
0991.7	11.1	Ba
1003.7	10.9	Ba
15.6	9.7	Ba
19.6	9.5	Ba
28.6	8.9	Ba
35.6	9.1	Ba
43.6	9.0	Ba

154639
V Cor. Bor.

J.D.	Est.	Obs.
0986.6	8.9	Bu
93.7	8.8	Ba
1003.7	9.2	Ba
15.6	9.1	Ba
15.8	10.1	M
19.6	9.3	Ba
28.6	9.1	Ba
31.6	10.3	M
35.6	9.9	Ba
43.6	9.5	Ba

154615
R Serpentis

J.D.	Est.	Obs.
0991.7	7.3	Ba
93.6	7.6	M
93.6	8.0	O
95.6	8.0	O
1003.7	7.6	Ba
04.6	8.0	O
05.7	8.1	Pi
09.6	8.1	O
11.7	7.2	Bl
13.6	8.1	O
13.7	8.1	R
15.6	7.9	Ba
16	8.4	ϒ
16.6	8.1	B
16.6	8.2	Ma
17.6	8.2	O
19	9.0	ϒ
19.6	8.0	Ba
21.7	8.1	Mu
25.7	8.7	R
27.6	8.3	Ba
32.7	8.5	Mu
34.7	8.2	M
35.6	8.7	Ba

R Serpentis

J.D.	Est.	Obs.
242		
1037.6	8.7	O
37.6	8.6	Ma
42.6	9.0	Wpi
42.6	8.8	Pi
43.6	8.8	O
43.6	9.0	Ba
46.6	9.0	O
51.6	9.3	O

154736
R Lupi

J.D.	Est.	Obs.
1033.6	10.1	Ba

154715
R Librae

J.D.	Est.	Obs.
1034.7	<11.2	M

155018
RR Librae

J.D.	Est.	Obs.
1011.7	9.0	M
42.7	9.1	M

155229
Z Cor. Bor.

J.D.	Est.	Obs.
0993.7	13.0	Ba
1015.6	<13.6	Ba
35.6	<13.0	Ba

155847
X Herculis

J.D.	Est.	Obs.
0988	6.9	Nt
1004.7	6.7	Mu
11.7	6.8	Mu
11.7	6.0	G
14.7	6.8	Mu
15	7.1	Nt
19.7	6.4	Mu
19.7	5.3	R
20.7	6.4	Mu
21.7	6.5	Mu
31.7	6.3	Mu
32.7	6.5	Mu
33.7	5.4	R
33.8	6.5	Mu
34.7	6.5	Mu
35.7	6.5	Mu
36.7	6.5	Mu
37.8	6.5	Mu
38.7	6.3	Mu
41	7.1	Nt
44	6.5	Nt

160021
Z Scorpii

J.D.	Est.	Obs.
0989.8	10.6	M

160127
RR Herculis

J.D.	Est.	Obs.
016	8.4	ϒ

160118
R Herculis

J.D.	Est.	Obs.
242		
0989.7	11.0	V
93.7	11.2	Ba
1005.6	12.0	Ba
08.6	12.0	B
15.6	11.9	Hu
15.6	12.9	Ba
37.6	13.4	Ba
37.7	<10.7	M

160210
U Serpentis

J.D.	Est.	Obs.
0991.7	11.0	Ba
1003.7	11.6	Ba
04.6	11.1	O
05.7	11.4	Pi
15.6	11.8	Ba
15.6	9.1	M
16.6	11.8	B
37.6	13.0	B
37.6	12.8	Ba

160221

J.D.	Est.	Obs.
0989.8	<11.1	M

160625
RU Herculis

J.D.	Est.	Obs.
0989.7	11.1	V
91.8	10.6	M
93.7	10.8	Ba
1003.7	10.8	Ba
08.6	10.7	V
15.6	9.8	B
15.6	10.7	Ba
19.7	10.6	V
27.6	9.6	Ba
33.6	8.6	Ba
36.7	8.3	Wpi
36.7	8.4	Pi
36.7	8.5	V
38.7	8.3	M
43.6	7.9	Ba

*161122*a
R Scorpii

J.D.	Est.	Obs.
1004.7	11.0	M
18.7	11.4	M

*161122*b
S Scorpii

J.D.	Est.	Obs.
1004.7	11.2	M
18.7	11.3	M

T Scorpii
161122c

J.D.	Est.	Obs.
1004.7	10.8	M
18.7	11.0	M

161138
W Cor. Bor.

J.D.	Est.	Obs.
242		
0990.6	11.9	B
93.7	<12.5	Ba
1010.6	12.2	B
33.6	11.3	Ba
37.6	11.2	Ba
45.6	11.1	Ba

161607
W Ophiuchi

J.D.	Est.	Obs.
1004.6	11.3	Ba
15.6	<13.0	Ba
37.6	<13.5	Ba

162112
V Ophiuchi

J.D.	Est.	Obs.
0993.7	7.9	Ba
1004.6	8.0	Ba
08.8	8.8	M
15.6	8.0	Ba
33.7	10.0	R
35.7	8.6	Ba
43.6	8.5	Ba

162119
U Herculis

J.D.	Est.	Obs.
0993.7	8.9	Ba
1004.6	8.3	Ba
04.7	8.3	Mu
05.6	8.3	O
07.6	8.2	Ma
08.6	8.4	Pi
09.6	8.0	O
09.6	8.3	S
11.7	7.5	Mu
11.7	8.0	M
11.7	7.9	Bl
11.7	7.5	G
13.6	7.9	O
13.7	8.1	R
15.6	7.4	Ba
15	7.7	Nt
15.6	7.4	B
15.8	7.7	M
16.6	7.6	Ma
17.6	7,7	O
17.6	7.4	Cr
17.7	7.6	Sc
19.6	7.2	Mu
21.7	7.0	Mu
25.7	7.7	R
27.7	7.2	Ba
32.7	7.1	Mu
35.7	7.1	Ba
35.7	7.0	Mu
36.6	7.2	Ma
36.6	7.8	Wpi
36.6	7.4	Pi
37.6	7.1	O
37.7	7.2	M
43.6	7.1	Ba
43.6	7.7	O

VARIABLE STAR OBSERVATIONS May, June, July, 1916—Continued

U Herculis

J.D. 242	Est.	Obs.
1045	7.2	Gr
46.6	7.6	O
51.6	7.8	O

162807
SS Herculis

J.D.	Est.	Obs.
0993.7	12.0	Ba
1004.6	11.1	Ba
08.6	11.3	B
10.7	10.9	Ba
15.6	10.9	Ba
27.7	9.9	Ba
33.7	9.8	Ba
36.7	9.3	V
38.7	9.7	M
41.6	9.4	Ba

162815
S Ophiuchi

J.D.	Est.	Obs.
1004.6	10.0	Ba
15.6	10.7	Ba
37.6	12.2	Ba

163137
W Herculis

J.D.	Est.	Obs.
0991.8	9.2	M
93.6	9.2	O
93.6	9.0	Ba
1003.7	9.0	M
04.6	9.7	Ba
08.6	9.7	B
09.6	9.5	Hu
09.6	9.5	S
15.6	10.0	Ba
17.6	9.7	O
27.7	10.5	Ba
35.7	11.2	Ba
36.7	11.4	Wpi
36.7	11.2	Pi
44.6	11.8	Ba

163172
R Urs. Min.

J.D.	Est.	Obs.
0993.7	9.1	Ba
1004.6	9.1	Ba
08.7	9.9	M
10.7	9.4	Pi
15.6	9.3	Ba
17.6	9.3	B
19.7	9.6	R
25.7	9.6	R
27.7	9.5	Ba
28.7	9.4	M
37.6	9.2	Ba
43.6	9.8	Pi
45.6	9.3	Ba

163266
R Draconis

J.D. 242	Est.	Obs.
0985.6	7.9	Cr
88.6	7.7	Ma
91.7	7.9	Ba
91.8	7.9	M
93.6	7.7	O
95.6	8.0	Ba
95.6	7.7	O
96.6	7.8	B
96.6	7.9	Cr
1001.6	7.9	Pi
02	8.2	Wh
04.6	8.4	Ba
05.6	8.0	Cr
07.6	8.1	Ma
08.7	8.8	M
09.6	9.0	S
09.6	8.7	O
10.6	8.5	Cr
13.6	8.8	O
13.7	8.8	R
15.6	8.8	Ba
16	8.7	Υ
16.6	9.0	S
17.6	9.1	O
17.6	9.3	Cr
19	9.2	Υ
25.7	9.8	R
27.6	9.6	M
27.7	9.5	Ba
33	9.6	Wh
35.6	9.8	S
35.7	10.2	Ba
44.6	10.8	Ba

164055
S Draconis

J.D.	Est.	Obs.
0991.8	8.5	M
1003.7	8.8	M
04.6	8.9	Ba
08.7	8.9	M
13.7	9.0	R
27.7	9.0	M
28.6	8.1	Ba
33.7	9.3	R

164319
RR Ophiuchi

J.D.	Est.	Obs.
1004	<12.0	Ba
1016.6	12.7	B
16.7	<13.0	Sp
44.7	12.9	B

164715
S Herculis

J.D. 242	Est.	Obs.
0991.8	8.0	M
93.7	7.9	Ba
1004.6	8.4	Ba
05	9.0	Wh
05.6	9.2	O
1008.6	8.7	B
08.6	9.0	Pi
13.6	9.5	O
13.7	9.1	R
15.6	9.0	Ba
17.6	9.5	O
27.7	9.9	Ba
33.7	10.0	R
34.7	10.0	M
35.7	10.1	Ba
37.6	10.0	O
44.6	10.5	Ba
45.6	10.1	O

165030
RR Scorpii

J.D.	Est.	Obs.
1010.8	11.3	Pi
33.7	<10.5	R
45	10±	Υ

165631
RV Herculis

J.D.	Est.	Obs.
0991.8	<11.2	M
93.7	<13.7	Ba
1004.6	<13.6	Ba
04.7	14.4	M
08.6	<13.6	B
14.8	14.2	M
35.7	<13.5	Ba
40.7	<13.7	M

170215
R Ophiuchi

J.D.	Est.	Obs.
0954	6.6	L
1004.6	8.1	Ba
05.7	8.2	Pi
08.7	8.1	M
11.7	8.0	Bl
14.7	8.7	R
15.6	8.3	O
15.6	8.4	Ba
16.7	8.4	Sp
27.7	9.0	Ba
33.7	9.3	R
35.7	9.8	Ba
36.6	9.1	Ma
38.7	9.5	M
43.6	10.4	Pi
44.6	10.0	Ba

170627
RT Herculis

J.D.	Est.	Obs.
0995.6	10.7	Ba
1004.7	10.7	Ba
08.6	11.1	B
15.6	10.9	Ba
28.7	11.0	Ba
35.7	11.3	Ba
37.8	11.4	M
44.6	11.5	Ba

171401
Z Ophiuchi

J.D. 242	Est.	Obs.
0989.7	8.4	V
95.6	8.5	Ba
1004.6	9.0	Ba
07.7	9.0	V
15.6	9.0	Ba
19.7	9.0	V
28.6	9.1	Ba
36.7	9.0	V
44.6	9.0	Ba
46.6	8.9	O

171723
RS Herculis

J.D.	Est.	Obs.
0989.7	8.4	V
95.6	7.9	Ba
1004.6	7.9	Ba
07.7	7.8	V
08.6	7.7	Pi
09.6	7.5	Hu
12.8	7.8	M
14.7	8.1	R
15.6	8.0	B
15.7	7.9	Ba
17.6	8.0	O
19	7.8	V
27.7	8.1	Ba
33.7	8.5	R
35.7	8.5	Mu
35.7	8.1	Ba
36.6	8.7	Pi
36.6	8.7	Wpi
36.7	8.4	V
37.6	8.8	O
38.7	8.6	M
40.7	8.7	M
43.6	9.1	O
44.6	8.5	Ba
44.7	8.9	M

172809
RU Ophiuchi

J.D.	Est.	Obs.
0989.8	9.1	V
91.8	9.3	M
95.6	9.0	Ba
1004.6	9.2	Ba
07.7	10.0	V
11.8	9.4	E
15.7	9.4	Ba
16.7	9.5	Sp
19.7	<9.6	V
28.6	10.0	Ba
34.7	11.0	M
35.7	11.0	E
36.7	<11.2	V
40.7	11.1	R
44.6	11.4	Ba

175111
RT Ophiuchi

J.D. 242	Est.	Obs.
0989.8	<11.0	V
1004.7	12.5	Ba
11.7	9.7	M
15.7	13.0	Sp
16.6	12.9	B
16.6	<12.5	Ba
38.7	<13.0	Sp
44.7	<13.0	Sp

175458
T Draconis

J.D.	Est.	Obs.
0989.8	<11.0	V
91.8	<10.4	M
1004.7	12.7	Ba
04.7	11.1	M
10.7	11.2	Pi
28.6	12.5	Ba
31.6	9.5	M
36.7	<10.4	V
44.6	11.6	Ba

175519
RY Herculis

J.D.	Est.	Obs.
1008.7	13.0	Ba
28.6	11.1	Ba
33.7	10.5	Ba
44.6	9.6	Ba

180531
T Herculis

J.D.	Est.	Obs.
0991.8	10.6	M
1004.7	11.5	Ba
10.6	11.1	Ba
15.6	10.8	O
21.6	9.6	Sc
28.6	9.3	Ba
34.7	9.5	M
35.7	9.3	Mu
37.6	9.1	O
37.6	8.8	Ma
40.7	9.5	R
43.6	8.7	O
44.6	8.4	Ba
51.6	8.5	O

180565
W Draconis

J.D.	Est.	Obs.
0991.8	<12.0	M
1001.6	<11.3	Pi
04.7	<12.5	Ba
10.6	13.0	B

180666
X Draconis

J.D.	Est.	Obs.
0991.8	10.7	M

VARIABLE STAR OBSERVATIONS May, June, July, 1916—Continued.

181103
RY Ophiuchi

J.D.	Est.	Obs.
242		
0989.8	8.0	V
1004.7	10.0	Ba
07.7	10.2	V
16.6	11.1	B
16.7	11.3	Sp
19.7	<11.7	V
36.7	<11.3	V
37.7	10.5	M
44.7	13.0	Ba

181136
W Lyrae

J.D.	Est.	Obs.
1003.6	12.6	B
04.7	12.3	M
04.7	12.6	Sp
05.6	<10.9	O
05.6	12.2	Ba
08.7	11.9	Sp
10	<10.5	Wh
15.6	11.8	Hu
17.7	11.9	Sp
19.6	11.9	Hu
21.7	11.3	Mu
27.6	11.0	M
31.7	10.6	M
32.7	11.2	Mu
35.6	10.3	B
35.6	10.5	Sc
35.7	11.2	Mu
1037.6	10.1	Hu
43.6	9.9	O
43.6	10.3	M
44.7	10.1	Ba
51.6	5.9	O

182224
SV Herculis

J.D.	Est.	Obs.
1008.6	12.3	B
16.7	11.7	Ba
28.6	10.3	Ba
33.7	10.4	Ba
44.6	9.8	B
44.7	9.9	Ba

182306
T Serpentis

J.D.	Est.	Obs.
1004.7	9.1	Ba
07.7	9.4	V
15.9	9.6	M
19.7	9.3	V
28.6	9.6	Ba
34.7	9.2	M
36.7	10.2	V
40.7	10.0	R
44.7	9.7	Ba

183225
RZ Herculis

J.D.	Est.	Obs.
1011.8	12.2	E
16.7	<12.5	Ba
17.6	<10.6	O
33.7	12.7	Ba
44.7	13.0	Ba

183308
X Ophiuchi

J.D.	Est.	Obs.
242		
0954	8.1	L
89.8	8.4	V
1004.7	8.3	Ba
07.7	8.5	V
08.6	8.5	Pi
08.7	8.2	M
15.7	8.4	Ba
19.7	8.4	V
27,7	8.2	Ba
33.7	8.1	Ba
36.7	8.4	V
37.6	8.4	Ma
37.7	8.1	M
40.7	8.3	R
41.6	8.0	Ba
44.7	7.8	Sp
45.6	8.0	Ba

184134
RY Lyrae

J.D.	Est.	Obs.
1019.6	<13.0	Ba

184243
RW Lyrae

J.D.	Est.	Obs.
1008.8	<13.7	Sp
08.7	<13.4	B
11.8	13.1	E
28.6	<13.0	Ba
44.6	<13.7	B

184205
R Scuti

J.D.	Est.	Obs.
0954	5.6	L
68	5.0	L
82	5.0	L
91.9	5.3	M
92.7	5.2	Pi
93.7	5.4	Ba
1004.7	5.7	Ba
08.8	5.2	M
10.6	5.9	Ba
10.8	5.5	Pi
11.8	5.9	E
15.6	5.9	Ba
15.6	5.7	Nt
19.6	5.9	Ba
27.6	5.6	Ba
28.6	5.7	Ba
32.8	5.3	M
33.6	5.7	Ba
35.6	5.8	Ba
35.8	6.0	Mu
35.8	5.5	E
37.6	5.6	Ba
37.8	6.0	Mu
38.8	5.4	E
39.8	5.9	E
40.6	5.5	Ma
40.7	4.9	R
41.6	5.7	Ba

R Scuti

J.D.	Est.	Obs.
242		
1041.8	5.9	E
43.6	6.0	O
43.6	5.7	Ba
44.6	5.2	Pi
44.6	5.7	Nt
44.7	5.6	Ma
45.6	6.0	O
45.6	5.8	Ba
46.6	6.0	O
51.6	6.4	O

185032
RX Lyrae

J.D.	Est.	Obs.
1010.6	13.8	Ba
14.8	14.3	M
41.6	<14.0	Ba

190108
R Aquilae

J.D.	Est.	Obs.
0991.9	9.9	M
1004.7	9.6	Ba
08.8	9.4	M
15.7	9.1	Sp
17.7	8.5	Sp
27.7	8.4	Ba
34.8	8.2	M
36.7	8.0	V
37.7	7.5	Sp
44.7	7.0	Ba

190529
V Lyrae

J.D.	Est.	Obs.
0993.7	10.6	Ba
1004.7	11.1	Ba
15.6	12.0	Pi
41.6	12.2	Ba

190926
X Lyrae

J.D.	Est.	Obs.
0995.6	9.1	Ba
1003.8	9.5	M
04.7	8.9	Ba
08.6	9.2	Pi
15.6	9.5	Pi
28.6	9.0	Ba
37.6	8.7	Ba
37.7	9.4	Ma
38.7	9.3	M
40.7	9.2	R
43.6	9.7	M
45.6	9.0	Ba
46.6	9.2	O

190967
U Draconis

J.D.	Est.	Obs.
0991.8	<12.1	M

191019
R Sagittarii

J.D.	Est.	Obs.
1010.8	11.4	Pi
11.1	10.2	Ho
44.7	8.7	Ba

191033
RY Sagittarii

J.D.	Est.	Obs.
242		
1010.8	<10.6	Pi
11.9	< 8.3	E
11.9	<11.5	Ho
37.7	<12.0	Ba
41.7	<12.0	Ba

191350
TZ Cygni

J.D.	Est.	Obs.
1005.7	10.2	Ba
23.6	10.4	Ba
43.7	10.5	Ba

191637
U Lyrae

J.D.	Est.	Obs.
1004.7	10.6	Ba
15.6	11.1	Pi
15.7	10.3	Ba
28.7	10.0	Ba
38.7	10.6	M
43.7	9.4	Ba

192928
TY Cygni

J.D.	Est.	Obs.
0995.6	10.0	Ba
1003.8	8.7	M
04.7	9.6	Ba
07.8	10.3	V
11.8	10.3	E
19.7	10.8	V
28.7	11.5	Ba
42.8	<11.2	V
43.6	10.0	M
43.7	12.0	Ba

193311
RT Aquilae

J.D.	Est.	Obs.
1004.7	9.1	Ba
15.7	9.0	Ba
16.6	9.6	O
28.7	9.2	Ba
28.8	8.0	M
43.6	9.9	O
43.7	9.1	Ba

193449
R Cygni

J.D.	Est.	Obs.
0989.8	9.8	M
95.6	9.0	Ba
97.7	9.0	Pi
1004.7	8.8	Ba
11.8	9.1	E
13.7	8.5	R
15.6	8.4	S
15.6	8.4	O
17.6	7.9	B
19.6	8.7	O
20.8	8·1	M
21.8	8.0	Mu
27.7	8.4	M
28.7	7.2	Ba

R Cygni

J.D.	Est.	Obs.
242		
1029.7	7.2	R
34	7.3	Wh
34.6	7.5	Pi
35.6	7.5	S
35.7	7.2	Mu
36.6	7.4	Ma
37.6	7.2	O
37.6	7.5	Cr
41.6	7.2	R
43.6	7.0	O
43.6	8.4	M
43.6	7.1	Ba
45	8.7	T
51.6	6.9	O

193509
RV Aquilae

J.D.	Est.	Obs.
1004.7	9.5	Ba
11.8	9.9	E
16.7	9.7	O
28.7	10.8	Ba
41.7	12.1	M
43.6	<10.5	O
43.7	12.2	Ba

193732
TT Cygni

J.D.	Est.	Obs.
0982	7.2	L
93.6	7.8	Pi
97.6	7.3	Ba
1004.7	7.2	Ba
08.8	8.2	M
11.8	8.1	E
19.7	8.0	R
28.7	7.2	Ba
34.6	8.2	Pi
42.6	8.1	Ma
43.6	8.1	M
44.7	7.4	Bu

194048
RT Cygni

J.D.	Est.	Obs.
0989.8	7.2	M
93.6	7.2	Pi
95.6	7.4	Ba
1004.7	7.7	Ba
11.8	7.7	E
13.7	8.1	R
15.6	8.0	O
15.6	8.3	S
15.7	8.0	Ba
19.6	8.2	O
20.8	8.4	M
21.8	8.2	Mu
25.7	8.8	R
27.7	8.7	M
28.7	8.5	Ba
34	9.0	Wh
35.6	9.1	S
35.8	9.1	Mu

VARIABLE STAR OBSERVATIONS May, June, July, 1916—Continued.

RT Cygni

J.D.	Obs.	Est.
242		
1037.6	9.3	Ma
37.6	9.1	O
43.6	9.3	Ba
43.6	9.6	O
43.6	9.8	M
45	11.2	T
51.6	9.7	O

194348
TU Cygni

0989.8	<11.2	M
1004.7	12.8	M
04.7	12.5	Ba
11.8	11.3	E
15.6	11.0	O
15.7	11.2	Ba
19.6	10.6	O
28.7	10.2	Ba
28.8	10.3	M
43.6	9.6	M
43.6	10.0	Ba

194604
X Aquilae

0989.8	9.9	V
91.9	9.3	M
95.8	9.3	Pi
1004.7	8.8	Ba
07.8	8.8	V
08.8	9.5	M
15.7	9.1	Sp
19.7	8.8	V
28.7	9.2	Ba
28.8	10.0	M
37.7	10.0	Sp
41.7	9.9	M
42.6	10.4	Pi
42.6	10.5	Wpi
42.8	9.9	V
43.7	9.7	Sp
44.7	9.8	Ba

194632
χ Cygni

0982	10.3	L
89.8	10.6	M
1005.7	11.0	Ba
11.8	11.4	E
15.6	11.0	O
15.7	11.5	Sp
15.7	11.4	B
17.7	12.0	Sp
19.7	<11.0	R
37.7	12.1	B
41.6	12.3	Ba

195116
S Sagittae

1035.8	5.4	Mu
37.8	5.7	O
43.6	5.8	O
46.6	5.9	O
51.6	5.9	O

195849
Z Cygni

J.D.	Obs.	Est.
242		
0989.8	<11.6	M
97.7	12.2	Pi
1004.7	12.5	M
04.7	12.5	Ba
10.7	12.2	Sp
17.6	12.5	B
17.7	12.3	Sp
21.8	<11.6	Mu
34.6	<11.6	Pi
35.7	12.5	Sp
37.6	12.5	B
41.6	12.7	Ba
43.6	11.6	M

200212
SY Aquilae

0991.9	10.7	M
1004.7	11.0	Ba
38.7	11.6	Sp
38.7	11.6	B
41.6	11.8	Ba
41.7	11.9	M
46.6	<10.8	O

200357
S Cygni

0997.7	<11.7	Pi
1004.8	14,1	M
15.7	<13.5	Sp
37.7	<13.5	Sp
41.6	<14.0	Ba
45.6	<10.7	O

200514
R Capricorni

1041.7	10.4	M

200647
SV Cygni

0989.8	9.0	M
95.6	8.8	Ba
95.7	8.8	Pi
1004.7	8.1	Ba
20.8	8.8	M
21.8	8.9	Mu
27.7	9.0	M
28.7	8.2	Ba
29.7	9.1	R
34.6	9.0	Pi
34.6	8.7	Wpi
35.8	9.1	Mu
41.6	9.2	Cr
43.6	9.3	Pi
44.7	9.2	Ma
44.7	8.0	Ba
45.6	9.1	Cr

200715a
S Aquilae

J.D.	Obs.	Est.
242		
0991.9	9.6	M
1004.7	9.5	Ba
16.7	9.7	Sp
28.7	9.5	Ba
37.7	9.8	Sp
41.7	10.7	M
43.7	10.1	Sp
44.7	9.9	Ba

200915b
RW Aquilae

0991.8	8.8	M
1004.7	9.4	Ba
16.7	9.6	Sp
28.7	9.1	Ba
37.7	9.0	Sp
41.7	8.9	M
43.7	9.0	Sp
44.7	9.1	Ba

200747
RX Cygni

1021.8	7.8	Mu
35.8	7.8	Mu
45.6	7.8	O

200822
W Capricorni

1015.9	<11.6	M

200812
RU Aquilae

1004.7	9.6	Ba
45.6	9.6	O

200916
R Sagittae

0991.9	9.9	M
1004.7	9.7	Ba
16.7	8.6	Sp
28.7	8.9	Ba
37.7	9.1	Sp
41.7	8.7	M
43.7	9.0	Sp
44.7	9.0	Ba

200906
Z Aquilae

1041.7	13.0	Ba
43.7	13.5	Sp

200938
RS Cygni

0982	7.0	L
89.8	8.5	M
1005.7	7.1	Ba
10.7	8.0	Pi
14.7	8.4	R
20.8	8.3	M
29.7	7.3	R
36.7	8.3	Wpi
36.7	8.6	Pi
41.6	8.0	Ma
41.7	7.3	Ba
43.6	8.7	M

201008
R Delphini

J.D.	Est.	Obs.
242		
1005.7	10.3	Ba
41.7	12.0	B
41.7	12.0	Ba
44.6	<10.4	Pi
45.6	<10.8	O

201121
RT Capricorni

1011.1	7.0	Ho
15.9	7.7	M
37.7	7.0	Ba
42.7	7.4	M

201139
RT Sagittarii

0982.1	7.8	Ho

201130
SX Cygni

0989.8	<11.4	M
1010.7	13.5	Sp
14.8	13.0	M
16.7	13.0	Ba
17.7	12.7	Sp
17.7	12.8	B
35.7	10.3	Sp
36.7	10.9	B
40.7	13.7	M
43.7	10.2	Sp
44.7	10.2	Ba

201647
U Cygni

0982	9.8	L
89.8	9.2	M
91.7	7.6	Ba
95.7	8.5	Pi
1004.7	7.8	Ba
14.7	9.6	R
15.6	9.5	S
20.8	9.4	M
21.8	9.4	Mu
27.7	9.7	M
35.6	8.6	Cr
35.8	9.5	Mu
37.6	9.8	S
37.6	8.8	Cr
39.6	9.5	Bu
39.6	9.5	Cr
41.6	9.4	Cr
41.6	8.0	Ba
43	8.2	Wh
43.6	10.0	Pi
44.7	10.2	M
45.6	9.0	O
45	11.1	T

202539
RW Cygni

0989.8	8.9	M
97.7	8.2	Pi
1004.7	7.8	Ba

RW Cygni

J.D.	Est.	Obs.
242		
1020.8	8.1	M
31.7	8.0	M
33	8.0	Wh
37.6	8.3	Ma
41.7	7.6	Ba
44.7	7.9	Cr

202817
Z Delphini

0989.8	10.8	V
1005.7	9.5	Ba
07.8	9.5	V
19.7	9.0	V
42.7	9.3	M
42.8	9.4	V
43.7	8.9	Ba
44.6	9.0	Pi
45.6	9.4	O

202946
SZ Cygni

0982	10.0	L
89.8	8.9	M
91.7	9.3	Ba
93.6	9.6	Ba
97.7	9.6	Pi
1005.7	8.8	Ba
10.7	9.2	Ba
14.7	9.9	R
15.7	9.3	Ba
16.7	9.5	Ba
19.6	8.8	Ba
25.7	9.8	R
27.6	9.4	Ba
27.7	10.0	M
28.6	9.6	Ba
32.7	9.4	R
33.6	8.9	Ba
33.7	9.0	R
35.6	8.9	Ba
40.7	9.3	R
41.6	9.2	Ba
41.7	9.9	R
43.6	9.7	Ba
44.6	10.0	Ba
45.6	10.5	Cr
45.6	9.9	Ba

202954
ST Cygni

0989.9	<11.7	M
97.7	<11.0	Pi
1010.7	12.4	Sp
14.8	12.4	M
17.6	12.6	B
38.6	12.1	B
40.7	11.9	M
41.7	11.7	Ba

VARIABLE STAR OBSERVATIONS May, June, July, 1916—Continued.

203226
V Vulpeculae

J.D.	Est.	Obs.
242		
0992.8	8.9	Pi
1005.7	8.7	Ba
27.7	9.2	M
41.7	8.7	Ba

203611
Y Delphini

1041.7	<13.3	Ba

203847
V Cygni

1005.7	12.8	B
14.8	12.3	M
40.7	11.4	M
43.7	12.4	Ba

203905
Y Aquarii

1039.8	12.0	M

204016
T Delphini

1014.8	12.8	M
38.7	9.9	Sp
40.7	10.5	M
43.7	10.1	Ba

204318
V Delphini

1005.7	<12.4	Ba
43.7	<12.8	Ba
45	11.5	ϒ

204405
T Aquarii

0982.1	8.1	Ho
1037.7	11.5	Ba
37.8	11.5	M

204846
RZ Cygni

1005.7	12.1	Ba
42.7	10.5	M
43.7	12.5	Ba

205017
X Delphini

1005.7	9.0	Ba
41.7	9.8	Ba
45.6	10.7	O

205923
R Vulpeculae

0989.9	8.8	M
92.8	8.8	Pi
1005.7	9.1	Ba
09.9	9.4	M
43.7	11.7	Ba

210129
TW Cygni

0989.8	<11.2	V
1045.6	10.0	B9

210116
RS Capricorni

J.D.	Est.	Obs.
242		
1011.1	8.4	Ho
15.9	8.1	M
37.7	7.9	Ba
37.8	8.0	M

210868
T Cephei

0986	10.1	L
1005.7	10.4	Ba
09.9	10.7	M
10.7	10.7	Pi
35.7	10.0	Ba
42.7	10.2	M
43.6	10.1	Pi
45.6	10.0	O

211614
X Pegasi

1037.7	14.0	Ba

211615
T Capricorni

1037.7	<12.7	Ba

213044
W Cygni

0954	5.5	L
68	5.9	L
82	5.9	L
1032.7	5.9	R
45 6	5.9	O

213678
S Cephei

1005.7	8.7	Ba
09.9	9.7	M
10.7	9.8	Pi
16.6	10.2	S
19.6	9.3	Hu
37.6	10.2	S
41,7	9.4	Ba
42.7	10.3	M

213753
RU Cygni

0991.9	9.0	M
97.7	9.2	Pi
1032.8	8.8	M
41.7	6.7	Ba

213843
SS Cygni

J.D.	Est.	Obs.
0954	8.1	L
68	11.7	L
82	11.8	L
89.8	<10.9	M
89.8	<11.3	V
91.7	10.7	Ba
91.8	9.8	Pi
91.9	10.0	M
92.7	9.6	Pi
242		
0993.6	9.6	Pi
93.7	9.6	Ba
93.7	10.2	Bu
95.7	9.8	Bu
95.7	8.7	Pi
96.7	9.5	Bu
97.6	8.3	Pi
97.7	8.3	Pi
97.9	8.3	M
1001.6	9.1	Pi
02.8	9.7	M
03.7	10.0	Ba
93.8	10.4	M
04	10.2	Wh
04.7	10.3	Ba
04.7	10.8	M
05.7	11.3	Pi
05.7	10.9	Ba
07.8	<11.3	V
08.8	12.0	M
10	<10.9	Wh
10.7	11.6	Ba
10.7	11.8	Sp
10.8	11.7	Pi
11.8	11.7	E
15.6	11.7	Pi
15.7	11.6	Ba
15.7	11.8	Sp
15.9	12.0	M
16.6	11.6	Ba
16.7	11.7	Sp
17.7	11.7	Sp
19.6	11.9	Hu
19.6	11.3	Cr
19.6	11.5	Ba
19.7	11.1	E
19.8	11.1	V
20.8	11.3	M
25.9	10.4	M
27.6	8 7	Ba
27.7	8.3	M
28.6	8.6	Ba
28.8	8.3	M
31.7	8.4	M
32.6	8.3	Pi
32.6	8.6	Ba
32.6	8.2	Wpi
32 8	8.4	M
33	8.4	Wh
33.4	8.4	ϒ
33.6	8.7	Ba
33.7	8.9	R
34	9.2	Wh
34.6	8.3	Cr
34.6	8.3	Pi
34.7	8.5	M
34.8	8.6	E
35.4	8.4	ϒ
35.6	8,7	Ba
242		
1035.6	8.4	Cr
35.7	8.7	Sc
35.7	8.6	Sp
35.7	8.4	S
35.8	8.6	E
36.7	9.2	Pi
36.8	8.5	Wpi
37.4	9.3	ϒ
37.6	9.4	S
37.6	9.1	Ba
37.6	9.7	Cr
37.6	9.0	Ma
37.6	9.1	O
37.6	9.3	Hu
37.6	9.3	B
37.7	9 3	Sp
37.7	9.3	M
38.4	10.0	ϒ
38.6	9.5	B
38.7	9.6	Sp
38.8	9.6	M
39.6	10.1	Cr
39.6	10.1	Bu
40.7	9.9	R
40.7	10.6	M
41.3	10.7	ϒ
41.6	10.9	Nt
41.6	10.6	Ba
41.6	10.1	M
41.6	10.9	Cr
41.6	10.5	B
41.7	10.4	Sp
41.7	<10.5	R
41.8	10.3	E
42.6	10.2	M
42.6	11.5	Pi
42.6	10.9	Cr
42.6	11.5	Wpi
42.8	10.6	V
43	10.6	Wh
43.6	11.2	Ba
43.6	11.3	B
43.6	11.5	Pi
43.7	11.1	Sp
43.7	10.4	M
44	10.6	Wh
44.6	11.5	Ba
44.6	11.4	B
44.6	11.2	Cr
44.6	11.2	Nt
44.7	11.1	Sp
45.6	11.6	Ba
45.6	11.1	Cr
44	11.4	ϒ

213937
RW Cygni

J.D.	Est.	Obs.
0982	6.2	L
89.8	7.8	M
97.7	7.8	Pi
242		
1010.7	6.8	Ba
32.8	7.5	M
43.7	7.2	Ma
43.7	7.4	Ba
45	8.0	ϒ

214024
RR Pegasi

1010.7	9.2	Ba
37.7	10.2	Sp
37.7	9.8	Ba
43.7	10.2	Sp
45.6	10.0	Ba

215605
V Pegasi

1037.7	<13.0	Ba

215934
RT Pegasi

0989.8	<11.3	V
1007.8	10.8	V
19.7	10.9	V
42.8	10.8	V
45.6	10.9	Ba

220412
T Pegasi

1037.7	9.8	Ba
41.8	10.4	E
45.6	10.2	Ba

220613
Y Pegasi

1041.8	<12.5	E

220714
RS Pegasi

1041.8	10.1	E

222439
S Lacertae

1010.7	8.2	Ba
41.7	9.2	Sp
41.7	9.6	Ba

225914
RW Pegasi

1037.7	12.8	Ba
40.8	12.6	M

230110
R Pegasi

1010.8	<10.1	Pi
40.8	12.4	M
41.9	<12.1	E

230756
V Cassiop

0997.8	8.8	Pi
1009.9	8.2	M
10.7	8.3	Ba
35.7	8.0	Ba
37.8	8.2	M
41.7	8.4	Sp
43.7	8.4	Ba

Variable Star Observations May, June, July, 1916—Continued.

231425			231508			233956			235350			235939		
W Pegasi			S Pegasi			Z Cassiop.			R Cassiop.			SV Androm.		
J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
242			242			242			242			242		
1032.9	8.6	M	1039.9	9.4	E	1010.7	12.2	Ba	1037.7	12.7	Ba	1010.8	<11.6	Pi
37.7	8.6	Ba	233335			37.7	9.5	Ba	235525			37.7	9.6	Ba
41.9	9.5	E	ST Androm.			38.9	10.0	E	Z Pegasi					
			0997.8	9.4	Pi	45.7	9.6	Ba	1037.7	12.6	Ba			
			1034.9	9.0	E				41.9	<12.4	E			
			37.7	8.6	Ba									

	May-June	June-July
No. of observations	953	1131
No. of stars observed	188	190
No. of observers	21	21

differ widely from the mean of several, special care in the identification of the variable is urged. This does not apply to the extremely red stars where a wide range of estimates seems unavoidable.

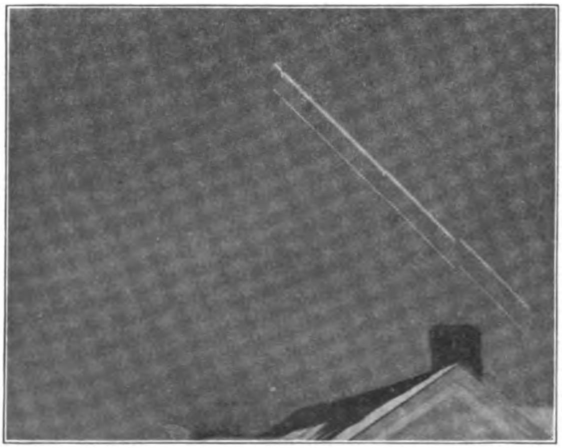
The following members contributed to this report:—Messrs. Bancroft, Baldwin, Bouton, Burbeck, Crane, Eaton, Gray, Gregory, Hoge, Hunter, Lacchini, Mach, McAteer, Mundt, Nolte, Olcott, Pickering, W. Pickering, Richter, Schulmaier, Vrooman, Whitehorn, Yendell, Miss Ludeke, and Miss Swartz.

William Tyler Olcott,
Corresponding Sec'y.

Norwich, Conn.
July 10, 1916.

COMMUNICATIONS.

Conjunction of Venus and Jupiter.—This picture of Venus and Jupiter was taken from a west window at Smith College, Northampton, Mass., on Monday, February 14, 1916. The film was exposed from six forty-five until seven thirty p.m.



Trails of Venus and Jupiter at Conjunction, February 14, 1916.

At this time the moon was eleven days old, half way between first and second quarter. The camera used was a Brownie 3A Folding, with ordinary magnifying power, adjusted at stop number 64, and focussed at one hundred feet. The camera was propped up with books so as to point in the right direction and so was jarred slightly three times by the opening of the door, as indicated on the print by breaks in the trails.

Two star trails were included, one to the right and one to the left, above Venus and Jupiter, the right hand one being gamma of Pegasus, according to a map made from the sky showing the relative positions on February 15.

MARGARET R. WILSON.

1918 Cortelyou Road,
Brooklyn, N. Y.

Meteor Observations from January to June 1916.—Being interested in meteor observations and watching all other meteor observers' results that are published in POPULAR ASTRONOMY I become more interested in the work every day. I have not seen any individual meteor results published by members of the American Meteor Society and would like to hear from some so as to compare results.

My own results are as follows:

Month 1916	No. of Nights	Total Time of observation h	m	Number of Meteors	Average per hour
Jan.	6	15	20	86	5.6
Feb.	11	27	25	142	5.2
March	10	23	5	107	4.5
April	7	18	7	141	7.6
May	11	25	50	332	12.9
June	6	17	10	270	15.8

JOHN KOEP.

Chippewa Falls, Wis.

GENERAL NOTES.

The editor is back at his desk after a very enjoyable semester spent at Harvard University. It has been a great pleasure not only to renew old acquaintances but to make many new ones, and to become familiar with the workings of a great institution, especially in astronomical lines, both of instruction and of research. To see the historic instruments of Harvard College Observatory and to actually use some of them, especially to see and make actual use of some of the enormous collection of photographs which has been accumulated there in the past 30 years, the value of which increases with each year that elapses, has been a privilege greatly appreciated.

It was our privilege also to visit the observatories at Wellesley, Mt Holyoke, Northampton and Amherst, and see the splendid equipment which all of these have for instruction in astronomy. One cannot help believing that such efficient teaching of astronomy in the colleges is bound to result in more wide spread popular interest in the subject in the near future.

Dr. Karl Schwarzschild, Director of the Potsdam Observatory, has died at Brussels at the early age of forty-three years. Dr. Schwarzschild was for a time in charge of the meteorological service at Brussels since its occupation by the German army. Later however he was transferred to the artillery and his death is said to be due to disease contracted while in service at the front.

Dr. Henry Norris Russell, Director of the Princeton Observatory, has been elected an Associate of the Royal Astronomical Society. No less than five American astronomers have been accorded this rare honor in the last three years.

Observatory Given to the Case School of Applied Science.—From the Cleveland *Plain Dealer* of June 29 we learn that the observatory owned by Ambrose Swasey and W. R. Warner is to be given to the Case School of Applied Science. The observatory now stands on Euclid avenue near east 79th street, between the home of Mr. Swasey and the adjoining house formerly occupied by Mr. Warner. It will be moved to the Case School campus, University Circle. The building will be enlarged by the building of two wings, one to be used as a laboratory for the measuring instruments, the other to contain a library and sleeping quarters for a student or professor. Mr. Warner and Mr. Swasey are to build these wings and equip them.

"The history of the observatory is as interesting as the instruments which it houses. It was built twenty-five years ago when Mr. Warner and Mr. Swasey first directed their attention to the manufacture of scientific instruments. It soon became a neighborhood center for those who are interested in the study of the heavens. Small classes met at the building for the study of astronomy.

"In addition to the use which will be made of the observatory in school work, the public will be admitted to it on certain nights each week."

NOTES FROM THE YERKES OBSERVATORY.

Mr. Georges Van Biesbroeck left the Observatory on June 15 after ten months of active participation in the regular work of the Observatory, chiefly in micrometric and photographic observations. He visited several observatories on his way to New York, whence he sailed on June 28. He hopes to be able to return to the Observatory at Brussels and resume his work there, desiring also to share with his family all the inconveniences caused by the war.

Mr. F. P. Leavenworth, of the University of Minnesota, is spending the summer at the Observatory as Professor of Practical Astronomy. He is chiefly engaged on micrometric work on double stars.

During the summer quarter **Mr. Everett I. Yowell,** of the Cincinnati Observatory, is acting as volunteer research assistant and is principally engaged in work on stellar parallax with the 40-inch telescope.

Miss Frances Lowater of the Department of physics, Wellesley College, is serving as volunteer research assistant for the summer quarter in work with Mr. Frost on the spectra of certain variable stars.

Mr. O. H. Truman of the Department of Astronomy, Iowa State University, is working in celestial photography and spectroscopy.

Mr. Max Petersen, graduate student in the Department of Physics, University of Wisconsin, is working on solar physics chiefly with the spectroheliograph.

Mr. C. C. Crump, of Carleton College is working during the summer quarter as assistant in stellar spectroscopy.

Miss Evelyn Wickham, who graduated from Vassar College in June, has begun her work as computer of stellar parallax at the Observatory.

Miss Vera M. Gushee, one of the graduates of 1916 from Smith College, begins similar work this month, and in September **Miss Hannah B. Steele,** recently research assistant at Swarthmore College, will begin her work here as assistant for stellar parallax.

ILLUSTRATED LECTURES

at the Yerkes Observatory on Monday Evenings during the summer
at 7:30 p. m. in July; thereafter at 7:00 p. m.

July 17	MR. O. J. LEE: Solar Prominences.
July 24	MR. E. E. BARNARD: Visual and Photographic Observations of Planets and Satellites.
July 31	MR. J. A. PARKHURST: Applications of Photographic Photometry: The Yerkes Actinometry; The North Polar Sequence.
Aug. 7	MR. E. E. BARNARD: The Star Clusters.
Aug. 14	MR. E. B. FROST: Peculiarities among Stellar Spectra.
Aug. 21	MR. C. C. CRUMP: Spectroscopic Binaries.
Aug. 28	MR. F. P. LEAVENWORTH: Notable Double Stars.
Sept. 4	MR. E. P. HUBBLE: The Nebulae.

PRELIMINARY LIST OF TOPICS PROPOSED FOR DISCUSSION AT THE MEETINGS OF THE YERKES ASTRONOMICAL CLUB IN JULY AND AUGUST 1916.

The Variability of the Sun (Abbot et al).	MR. LEMKOWITZ.
Magnetic Field in Sunspots and the general Magnetic Field of the Sun (Hale et al).	MR. PETERSEN.
The Stark Effect and its Possible Bearing on Stellar Spectra	MR. HUBBLE.
Temperature of Stars as indicated by their Spectra	MISS LOWATER.
Determination of Distances of Stars based upon their Spectra (Adams)	MR. CRUMP.
Kapteyn's "Plan of the Selected Areas" and its present Status	MR. YOWELL.
The Solar Apex	MR. TRUMAN.
Symposium on Stellar Proper Motions.	

CURRENT REPORTS.

"A Small Star with a Large Proper Motion"	MR. BARNARD.
Baillaud's Surface Photographic Photometer	MR. PARKHURST.
The Spectroscopic Binary 66 Eridani	MR. FROST.
Observations of the Radial Velocity of Gamma Lyrae	MR. CRUMP AND MR. LEMKOWITZ.
Radial Velocity of R Coronae	MR. FROST AND MR. HUBBLE.
Observations of Mira Ceti and R Leonis	MR. FROST AND MISS LOWATER.

Numerous other current reports may be expected, together with reviews of books.

At Yerkes Observatory January to June 1916.

HOURS OF OBSERVATION WITH 40-INCH TELESCOPE.

Month	1916	Mean for decade (1903-12)	Gain 1916
January	148	133	+15
February	141	125	+16
March	143.5	126.5	+17
April	134	120.5	+13.5
May	139	122	+17
June	123.5	133.5	−10
Total	829 hours	760.5 hours	68.5 hours

RAINFALL.

	Inches		Millimeters	
Month	1916	Decade	1916	Decade
January	4.05	1.52	103	38.6
February	.64	1.32	18	33.5
March	2.75	1.80	71	45.7
April	1.71	2.95	43	74.9
May	4.14	3.58	106	90.0
June	5.93	2.61	151	66.3
Total	19.22	13.78	492	350.0

Excess of Rainfall in 1916 = 5.44 inches or 142 millimetres.

A Faint Star with large Proper Motion.—Professor Edwin B. Frost, Director of the Yerkes Observatory, writes:—"From a comparison of his photographs taken with the 10-inch Bruce telescope, with the aid of the Zeiss blink-mikroskop, Professor Barnard has just discovered a star of the 11th magnitude having the remarkable annual proper motion of about $10''$. The position of the star for 1916.0 is $17^h\ 53^m\ 44^s$, $+4^\circ\ 27'.4$. This star follows B. D. +4°3560 by $9^s.5$ and is $0'.4$ north. The star is shown on several plates, one taken as far back as 1894 August 24, with the 6-inch Willard lens (at the Lick Observatory). The motion is almost directly north. The exact value of the motion will be published later."

The motion is confirmed by numerous Harvard photographs, the first of which were taken on May 22, 1888, and August 8, 1890.

The following position of Wolf's comet has been received here:—

G. M. T.	R. A.	Dec.	Observer	Place
	h m s	° ′ ″		
May 27.6893	12 29 48.60	+4 18 17.4	Barnard	Yerkes Observatory

EDWARD C. PICKERING.

Harvard College Observatory,
Bulletin 613. June 7, 1916.

NOTE:—An account of this star with photographs by Professor Barnard will be published in the next issue of POPULAR ASTRONOMY.

The Annual Conference of the Society for Practical Astronomy. The annual conference of the Society for Practical astronomy will be held in Rochester, New York, on August 24, 25 and 26 at the Bausch and Lomb Observatory. Rochester is a city of interest in optical matters and the meeting promises to be a success.

Latimer J. Wilson; president of the society, and director of the Planetary and Lunar Section is spending the summer at the observatory, where the eleven-inch refractor is being used for planetary and other observational work.

The Van Vleck Observatory of Wesleyan University at Middletown Conn., was dedicated on the afternoon of June 16, with the following order of exercises:

A WORD OF WELCOME

WILLIAM ARNOLD SHANKLIN

President of Wesleyan University

PRAYER

WILLIAM NORTH RICE, '65

Professor of Geology in Wesleyan University

THE FUNCTION OF THE VAN VLECK OBSERVATORY

FREDERICK SLOCUM

Director of the Van Vleck Observatory

ASTRONOMICAL RESEARCH AS NATIONAL SERVICE

GEORGE ELLERY HALE

Director of the Solar Observatory of the Carnegie Institution of Washington

ADDRESS

EDWARD BURR VAN VLECK, '84

Professor of Mathematics in the University of Wisconsin

UNVEILING OF TABLET

MASTER JOHN HASBROUCK VAN VLECK AND JOSEPH VAN VLECK, III.

THE DEDICATION

PRESIDENT WILLIAM ARNOLD SHANKLIN

The addresses were followed by a reception in the observatory library, and a general inspection of the building.

The observatory is the gift of the late Joseph Van Vleck, brother of the late Professor John Monroe Van Vleck, and is located on the top of a hill about three hundred yards due west of the Chapel. It is constructed of Portland brownstone.

The main part of the building is 40 by 80 feet, one story high, and contains a class-room, library, time-room, computing room, director's office, and an assistant's room. In a wing extending to the west is a transit room, containing two three-inch transits. At the end of a second wing, extending to the east, is the tower and dome for the chief instrument, a telescope of 18½ inches aperture, and 26 feet focal length. The completion of the lens for this instrument has been delayed by the war, and the 12-inch lens from the old observatory will be used temporarily in the new mounting.

For convenience in observing, the floor of the tower is an elevator, 33 feet in diameter, with a vertical range of 10 feet.

The basement contains two rooms for photographic work, a spectroscopic laboratory, and a workshop.

In addition to the telescope and two transits mentioned above, the observatory has a good equipment of apparatus for instruction and research. This includes three portable refractors, two spectroscopes, filar micrometer, photometer, altazimuth instrument, reflecting circle, two sextants, a 4-inch photographic doublet, two clocks, two chronometers, chronograph, comparator for photographic plates, and a computing machine.

The American Astronomical Society.—The nineteenth meeting of the American Astronomical Society will be held in the Sproul Observatory at Swarthmore, Pennsylvania, from Wednesday, August 30 to September 2, 1916. Not since the Washington meeting of December 1911 has there been a meeting east of the Alleghenies. Since then we have met in Pittsburgh just at the gateway to the early west, in Cleveland, in the south at Atlanta, in Evanston, and on the Pacific coast. The return to the East, the attractive programme, the opportunity to see two great, active observatories should bring out a record attendance. As Swarthmore affords inadequate hotel facilities at this season of the year arrangements have been made to accomodate the members in the college dormitories. In this way sleeping quarters, parlors, dining room, and the Observatory will be separated by not more than three minutes walk. The total cost for members coming for lunch on Wednesday and remaining until after lunch on Saturday, including all accomodations, will be $9.00. If on Friday we have luncheon at the Washington Inn at Valley Forge there will be be a charge of $1.00 the person. Professor Miller writes concerning recreation, that the tennis courts of the college will be accessible, that the swimming pool will be open, and that the Spring Haven Country Club, two miles away from the College, offers facilities for golf. Reservations for rooms should be made directly to Professor Miller. [From the Preliminary Announcement by Secretary Fox.

Falsifying the Time for the sake of Economy.—It has been called to our attention that a bill has been introduced in Congress, the purpose of which is to advance the hours of business by one hour during the summer time, not by changing the "legal" hours, but by the device of having all public clocks set ahead one hour.

This has been done in Germany, France and England, under the pressure of war expenses, on the theory that the reduction of the use of gas and electricity for one hour each night means in the aggregate an enormous saving. In the winter, late fall and early spring, the saving in the evening would be offset by the necessity of an extra hour of artificial illumination in the morning, so it is proposed to set the clocks back to correct time during that season.

We have nothing to say as to what action should be taken in other countries, but it seems to us that there is no need for this change in the United States, indeed that the change would be very objectionable.

Leaving out all astronomical considerations, where uniformity of time-reckoning is paramount, it would seem that in a country of such extent as the United States the annoyance resulting from the unavoidable confusion in both business and home life, attendant upon a sudden change of time twice a year, would more than balance the trifling saving to each person. In this country we have four divisions of Standard Time to which the people have become accustomed and which can cause little inconvenience if left undisturbed from year to year. To change all these twice a year could hardly fail to produce an immense amount of confusion.

The arrangement of the hours of Standard Time is an artificial one, it is true, but it is a perfectly definite one and goes on from year to year just the same. The proposed arrangement is objectionable because of the inconstancy of the definition of the time under it and because of the change it demands arbitrarily in personal and business habits twice a year.

It has been argued in favor of the change that working people would have more hours of daylight for recreation in the evening. We fancy that most working people would prefer the extra hour of rest in the morning. In fact, our own experience with the hot spell through which we are just now passing, leads us to argue that it would be *criminally cruel* to force the poorer people, who must go to their work *by the clock* in the morning, to go to bed an hour earlier on the sweltering hot nights in July and August, in rooms that have little ventilation, and deprive them of an hour in the cool of the morning, the only time on many summer nights when restful sleep is possible.

Annals of the Dearborn Observatory.—Volume I of the Annals of the Dearborn Observatory of Northwestern University, Evanston, Illinois, has just come to hand. It is a quarto volume of 229 pages, giving a general account of the Dearborn Observatory, a study of the quality and the color curve of the 18½-inch objective of the telescope and a large number of measures of double stars by the director, Philip Fox. We congratulate Professor Fox on the publication of the first volume and hope it may be succeeded by many others in the years to come.

Observation of Sun Spots at Boston University.—Between September 23, 1915 and May 11, 1916, observations of sunspots were made at the Boston University Observatory on 53 dates. Spots were visible on all the days. The method of observation was the same as that described in POPULAR ASTRONOMY 229.

The weather conditions interfered with the work to a considerable extent. The resulting incompleteness of the record makes definite conclusions impossible. It may be of interest, however, to note certain results and make some comparisons with the observations of last year.

Sixty-six groups containing 361 spots were seen. The average number of groups for each observation increased from 0.67 last year to 1.24 this year, while the average number of spots increased from 3 to 6.8.

Between longitudes 140° and 210°, which includes the region where no spots were seen last year, 23 groups were seen, representing more than one third of all those observed. Between 0° and 90° there were 15 groups with 55 spots; from 90° to 180° 27 groups with 118 spots; from 180° to 270° 18 groups with 102 spots; and from 270° to 360° 9 groups with 86 spots.

Thirty-three groups with 203 spots were observed north of the equator; 33 groups with 158 spots, south. Four spots were seen within ten degrees of the equator; two north and two south. Between 10° and 20° north and south there were 22 and 19 groups respectively; between 20° and 30°, 6 north and 11 south. Three groups were seen having a latitude of more than 30° north.

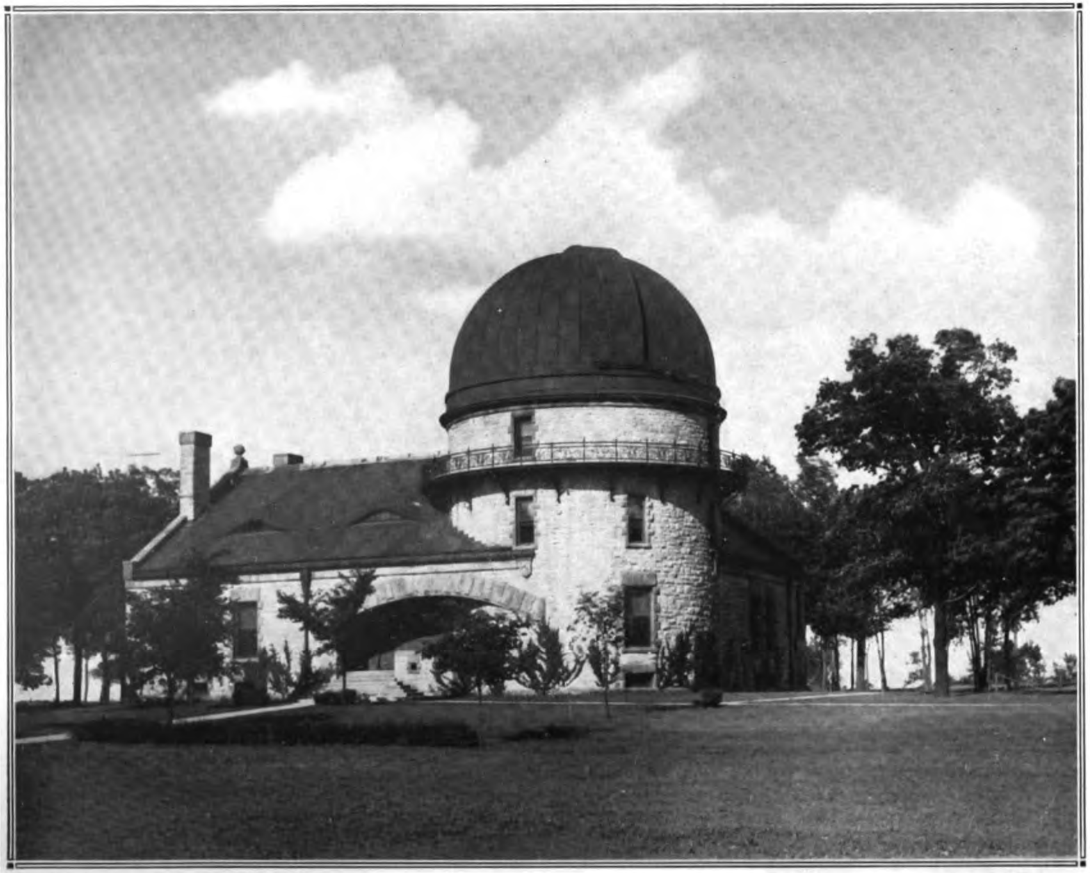
Last year in the region from 120° to 210° no spots were seen in north latitude. and but one in south. This year that region contained an abundance of spots which were about equally distributed between north and south. The only sections this year without spots were in the north from 15° to 65° and from 218° to 260°. These same areas in the south, however, showed large groups.

The average latitude this year showed a drift since last year of about five degrees toward the equator, slightly more pronounced in north latitude. Four groups were seen within 10° of the equator, while none were seen in that region last year. There was a slight display of spots in latitudes higher than any observed last year.

In regard to the character of the groups, the most decided change was an increase in the number of groups containing a large number of nuclei.

PRISCILLA FAIRFIELD.

PLATE XXVIII



THE DEARBORN OBSERVATORY OF NORTHWESTERN UNIVERSITY

Popular Astronomy.

Vol. XXIV, No. 8. OCTOBER, 1916. Whole No. 238

THE SEMI-CENTENNIAL OF THE DEARBORN OBSERVATORY.

PHILIP FOX.

On November 6, 1912 the Chicago Astronomical Society met at the Dearborn Observatory in observance of the completion of fifty years of its existence.* The foundation of this Society inaugurated the movement towards the erection of the Dearborn Observatory in Chicago. The Observatory was completed and the telescope in place on April 11, 1866, and on that evening the members of the Society and guests assembled with the Director, Professor Truman H. Safford, to make the first observations. This marked the end of the preparation and the commencement of the active work of the Observatory. On April 11 of the present year, the fiftieth anniversary of this event, commemorative exercises were held at Northwestern University.

Volume I of the Annals of the Dearborn Observatory, recently issued, contains a brief history of the Dearborn Observatory, so that here the account may be condensed to the following paragraph:

Under Professor Safford's direction the work of the Observatory went forward actively until the great Chicago Fire of 1871 prostrated the city and robbed the Observatory of its support. Shortly thereafter Safford withdrew and entered the U. S. Coast and Geodetic Survey, later going to Williams College. Professor Elias Colbert, who had been Assistant Director, assumed active charge, and with the exception of a few months in 1876, when Mr. S. W. Burnham was Acting Director, remained in charge until the appointment of Mr. G. W. Hough to the directorship, on May 6, 1879. In 1881 the University of Chicago became involved in litigation over its property and, as a consequence, in July

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* Pop. Ast. **21**, 473, 1913.

1887 the Observatory was notified to vacate its holdings. On August 10, 1887, a contract between the Society and Northwestern University was made, and shortly thereafter the instruments were transferred to Evanston and placed in the Observatory built through the gift of Mr. James B. Hobbs. Professor Hough actively conducted the observing until his death on January 1, 1909. Professor Malcolm McNeill of Lake Forest University was in charge until the appointment of the present Director, on September 1, 1909.

The programme of the evening consisted in a series of addresses designed to review the progress of astronomy during the past fifty years, the lifetime of the Dearborn Observatory. They covered the four great phases: historical, observational, mathematical, and astrophysical, as will be seen by the programme and by the addresses themselves which are here reproduced in full. Professor Barnard's address was accompanied by numerous lantern slides. Unfortunately these illustrations cannot be reproduced here.

PROGRAMME

Greetings from the University	President A. W. Harris
The Early Years of the Dearborn Observatory	Professor Elias Colbert
Some Reflections on the Progress of Astrophysics	Professor George Ellery Hale
The Progress of Mathematical Astronomy	Professor Forest Ray Moulton
The Advances of Observational Astronomy	Professor Edward E. Barnard

Address by Professor Elias Colbert.

The Early Years of the Dearborn Observatory.

It has been requested by the Director of the Observatory, that I glance briefly at the early incidents of the formation of the Chicago Astronomical Society, the acquisition of the telescope, and of the early years at the "First Dearborn Observatory." I accede willingly, because I believe that I am the only person now living who can speak from personal recollection of the earlier part of that history: though I am something like Fagin, when he said "A very old man, my lord."

Near the close of November, 1862, Professor M. R. Forey came from New York to the University of Chicago, hoping to sell a Fitz telescope for about $8000.00. A conference with President Dr. J. C. Burroughs, Professor A. H. Mixer, Mr. J. Young Scammon, Mr. Thomas Hoyne, and a few others, resulted in a meeting in Bryan Hall, then the largest in the city, on Monday evening, December 8. I was there, on the platform, but only as a reporter for the Chicago Times. Professor Forey addressed a full house. Then the Astronomical Society was organized, with Messrs. Scammon and Hoyne as President and Secretary. Subscriptions were liberal, for those days; $500.00 paid for a life Directorship, and $100.00 for a Life Membership; no astronomical knowledge being required from either members or officers. Members were to have the right to visit the Observatory one night in the week with their families.

William Harvey Wells was then Superintendent of Schools in Chicago. He was elected Vice-president of the Society (I think) at the first meeting. From him I learned that there was some reason to doubt the wisdom of buying the Fitz glass. I stated *that* (and some other things) in an article in the "Times" of December 20 following. "Quite a noise" resulted, including a visit to me by Mr. Hoyne at the office, and the belief that I knew more on the subject than they previously had given me credit for.

Then, January 23, 1863, our Mr. Hoyne paid a visit to Alvan Clark at his home in Cambridge, near Boston, who had for sale what was then the biggest and best refracting telescope in the world. Of course, it is well known that larger ones have been made since then: It was made by Alvan Clark & Sons (glass brought from near Birmingham, England) for the University of Mississippi: But the contract fell through because of the war of the rebellion, and now the glass was already famous, the companion to Sirius having been discovered through it about a year previously. It cost our Society $18,187.00, including $7,187.00 for mounting it here. It was understood to have an aperture of 18¾ inches and a focal length of 23 ft. 2 in. Then Mr. Scammon magnanimously offered to pay for the building of an observatory on condition that it be named "The Dearborn" after his first wife—a near relative of whom, General Dearborn, had been U. S. Secretary of War long before Chicago was a city.

I believe that a brother-in-law (name forgotten) of Elihu Burritt, the learned blacksmith, was Professor of Astronomy previous to May, 1865, when Professor Truman Henry Safford was chosen by the Directors of the Society as Director of the Dearborn Observatory, and became Ex-Officio Professor of Astronomy in the University. I met him a few times, but only as I was City Editor of "The Tribune". (Changed from "Times" to "Tribune" in 1863). Safford and I got acquainted easily and we two were together when, fifty years ago, Alvan Clark turned over the telescope to Safford as completely ready for use. I believe I took the very first peep through the tube after that. I wrote that up for the Tribune. The instrument worked all right, but the dome was a mechanical failure. It worked badly from the start and was a working horror until I raised the money to build a new one in 1875. There was no Meridian Circle until, I think, 1868, when one, the gift of Ex-Mayor Walter S. Gurnee, was placed in position.

In August 1869, Professor Safford and I went together to Des Moines, Iowa to observe the total solar eclipse on the 7th of that month. As a sequence to that, he and I agreed to establish a time service in Chicago. I raised the money needed to build a clock in the City Court House tower, to be connected by wire with the Observatory and also with several local jewelers. Soon after that was begun, the Society declared me to be Emeritus Assistant Director of the Dearborn Observatory. We had built the clock in place and the reflectors to the dials were at Toledo on the way to Chicago on the night of the great fire of October 8, 1871, which burned down the clock with the Court House. The University and the Observatory building, were untouched by the fire. They were outside its limits.

The great fire burned up the records of the Society and its balance in bank. A large percentage of the property burned had been insured in "Home Companies" which could not pay, etc., etc., etc. There was no money with which to pay the salary of the Professor as Director of the Observatory, and he was obliged to find work elsewhere. In the two and one-half years succeeding the fire he taught astronomy at Beloit, Wis., and did some surveying work in the Western States for the U. S. Government.

March 16, 1874, the Society held its first meeting since the great disaster. At that gathering Professor Safford submitted a report giving the mean declinations of 981 stars for January 1, 1875, and was granted leave of absence for two years, as he had received an offer of an appointment by the Government of the United States. Then I was declared to be Emeritus Director of the Observatory. Early in the next month I began teaching in the University as Professor of Astronomy. I continued that for five years, giving to the work about all the time I could spare from daily work on the Tribune, the governing power of which paper had consented thereto without any request from myself.

In those five years I worked gratuitously to increase the membership of the Society, build up a new dome over the big telescope and build up a time service. I succeeded well enough to be able to inform the Society that it could well afford to pay a better man than myself to do the work, was assured that the same would not think of choosing another man if I would consent to take pay and do the work, and I refused the offer with thanks. Then I nominated Professor G. W. Hough as Professor Safford had obtained a situation in Massachusetts, which he declined to leave. Subsequently I have had the honor to nominate Professor Philip Fox, the present incumbent, who succeeded soon after the decease of Professor Hough.

ADDRESS BY PROFESSOR E. E. BARNARD.

A FEW ASTRONOMICAL EVENTS OF THE PAST FIFTY YEARS.

The great civil war between the North and South placed the Dearborn telescope in Chicago. Its original destination was the University of Mississippi, for which it had been ordered before the outbreak of the war, but the consequent impoverishment of the finances of the university prevented the final purchase of the instrument.

In connection with this statement an interesting question might be raised as to what effect this change of destination had on the subsequent history of the telescope. The instrument is famous through the double star work of Burnham and Hough. With it they discovered many of the most interesting of the double star systems. Had there been no war the telescope would have gone south. Would it have found there a Burnham to immortalize it? In all probability no. It has always been an active instrument. Even now, though giant telescopes have risen in the later years of its life that far surpass it in power, it is still an important instrument and not only keeps up the traditions of the older astronomy in the observations of double stars but dressed in a new suit, as it were, and inspired by new accessories in the able hands of Professor Fox, it resolutely faces some of the most important problems of the newer astronomy.

But my time will not allow me to dwell upon the career of this telescope which the fortunes of war so greatly affected. Its career has been a brilliant one and really began before the instrument was actually finished, for it was while testing the telescope before its final completion that the younger Clark discovered with it the companion to the great star Sirius. This discovery was of high importance, mainly because it verified a theory that had been held for some time that such a companion star must exist to account for the irregular motion of Sirius through space.

Let me linger here for a moment on some facts connected with this discovery, for they are pertinent now. Four years ago marked the semi-centennial of the finding of this important star. Its period of revolution about Sirius is very close to fifty years, and it has made a complete circuit about the great star since its discovery. The event, therefore, that we celebrate today synchronizes with the period of this wonderful star. Thus is the life history of the Dearborn telescope woven in with the motions of some of the stellar systems.

Even when one necessarily leaves out the wonderful work of the spectroscope, it is impossible, in the time allotted me to more than briefly refer to a few of the remarkable things that have been done in the field of astronomy in the past fifty years. To recognize all of these, or even a considerable portion of them, would require a catalog of events. Such a dry compilation would be tedious to make and would be far more tedious to listen to. I have, therefore, thought best to confine myself to a recitation of a few of the more interesting facts and to make no attempt to cover the growth of astronomy in general in the time. It is difficult to crowd fifty years of anything into twenty minutes of time!

The advance of astronomy in the last fifty years is due mostly to new methods of research and to increase in optical power, but mainly to new methods and new accessories, all of which, however, depend upon the telescope. It is pleasing to see that the reflecting telescope, which had been relegated to the amateur, has again come into its own. It has, from many points of view, become one of the most important instruments in astronomy. It more readily lends itself to these various accessories of research in some ways than the refractor and it is all supreme for photographing the nebulae. Nowhere is this fact so splendidly shown as at the Solar Observatory of the Carnegie Institution at Mount Wilson in Southern California, where Professor Hale has erected the great 60-inch reflector, and where he is soon to have in operation a reflecting telescope of 100 inches aperture—a telescope over eight feet in diameter, the largest ever made. One of the most remarkable facts in connection with these two great instruments—along with others in use on Mount Wilson—is that they were made in the shops of the observatory in Pasadena. Some of these instruments, such as the great tower telescope, are unique, and show the wide diversity of Professor Hale's genius in devising extraordinary and successful means of research.

The work of the great telescopes of the Yerkes and Lick observatories under the direction of Professor Frost and Professor Campbell respectively has been of the highest importance in the advancement of all branches of astronomy. A large part of the work with these great instruments is spectroscopic and hence out of the reach of my subject tonight. Both these telescopes have contributed greatly to double star astronomy in the hands of Professor Burnham.

But if we speak of the progress of astronomy in the past fifty years, we must constantly refer to photography, for without it the progress would have been relatively small. It comes down really to a statement of what photography has done for astronomy. Photography as it was when the Dearborn Observatory was young could never have done much for astronomy. It has passed through two periods, the wet and dry processes. It was in the earlier period at that time, where the plate must remain wet throughout the process of making the negative, and was relatively very slow in its action. As the plate must remain wet, long exposures could not be given to overcome the want of sensitiveness. At that time, in the hands of Rutherford, it had pictured the surface of the Moon and had recorded the spots on the Sun. In both these cases there was plenty of light. It had had a try at the stars but with little success. It had attempted to show the great comet of 1858 but had made a failure of it. No one had even hoped that it could register the forms of the fainter nebulae. It had made no promise to the spectroscope, which itself was just beginning to awaken to the marvels of astronomy. In a word, it had not yet risen to be the "hand maid" of all the sciences and to become a science itself.

In the application of photography to almost every branch of astronomy the Harvard College Observatory, under the administration of Professor E. C. Pickering, has attained to the very highest importance. The collection of photographs of the sky obtained there and at the Harvard Station at Arequipa covers the entire heavens many times over. In the case of the discovery of a nova (and many of the novae have been discovered there) its early history and the actual time of its appearance within close limits are always found on the plates of this one observatory. The entire history of a variable star can be traced back almost from day to day for many years and in some cases for over a quarter of a century. The great increase in the discovery of variable stars, as one example, is due almost entirely to the ease with which every part of the sky can be compared at different times —days or months or years apart—and thus any change in the light of the stars can be noted. It was by this means that Professor Bailey of the Harvard College Observatory found that some of the great clusters of the sky contained many variable stars, the period of whose light changes was, in most cases, short and regular. In the cluster M 5 most of the variables have a period of about half a day. Their normal state is faint, from which condition they suddenly begin to brighten, like one awakening from sleep, and rise rapidly in an hour's time to their full brightness and then slowly sink to rest again—their active period being only a small part of their entire light change. A large number of these small stars range through about one magnitude, from 14½ to 13½ magnitude. If one watches this cluster on any one night with a powerful telescope he will see some of the stars in it increasing in brightness while others are fading to obscurity, as if in it were scattered a number of fireflies! But what does it all mean and what is the wonderful mechanism in the far depths of space that makes so many of these stars quickly awaken to life and then slowly sink to rest again? And why should their light variations and their periods be so nearly the same? Perhaps the most prolific of these clusters in variable stars are Omega Centauri and M 5. In each of these there are a hundred or more variables known.

Though no new worlds, in the ordinary sense, have been discovered, there have been added to the known worlds at least eight new moons, five to the planet Jupiter, one to Saturn and two to Mars. Five of these are due to the sensitive photographic plate. At least two of them have not yet been seen with the human eye.

The known asteroids, or small planets, which lie in a zone between the orbits of Mars and Jupiter, have increased rapidly until not far from a thousand are now known. The discovery of these small bodies since 1892, when Dr. Max Wolf first found one by the new process, has been almost wholly due to photography. New ones are constantly being found. Sometimes as many as five or six are shown on one plate.

The most interesting of these planets is Eros, whose mean distance is less than that of Mars and which can come within some thirteen millions of miles of the earth. This small planet has already given us a new and accurate value of the solar parallax and is destined at a favorable opposition to give a still more accurate value. A group of these small bodies has been found which have a mean distance greater than that of Jupiter. The smallness of many of these little planets thus found gives the impression that there must be many thousands of them, perhaps hundreds of thousands, ranging all the way from five hundred miles in diameter to the size of grains of sand.

Our knowledge of the Sun has increased tremendously in recent years. This has been due almost entirely to the spectroscope and to its application to the spectroheliograph. But this has already been dealt with tonight by a master of the subject.

Perhaps the only department of astronomy not seriously affected by photography is that of the double stars, where the eye at the telescope is still greater than the photographic plate. The progress in double star work is due mainly to visual observations. In late years Aitken, of the Lick Observatory has achieved remarkable success in this department of the older astronomy. But the sensitive plate is even trying to encroach on the work of the double star observer. The most interesting systems, however, with one or two exceptions, are at present beyond its reach.

The spectroscope has introduced to us a new class of double stars, whose periods in many cases are only a few hours or a few days, and which will never be seen separately with any telescope.

The development of planetary astronomy has not been in keeping with the rapid progress of the science in almost all other directions. This has been due mainly to the fact that, as in the case of the double stars, the magnifying power of the telescopic eyepiece is a necessary factor in the work. The direct image formed by the object glass must be magnified before the components of a close double star can be seen —and the close double stars in general are the most interesting. In the same way the unmagnified image of a planet is so small—even in the largest telescopes—that the surface features either cannot be seen or are so crowded together that they become one on the photograph. To overcome this difficulty the direct image of a planet must be magnified before it falls on the sensitive plate. Much progress has been made in this direction by the use of a secondary enlarging lens which projects an enlarged image of the planet directly on the plate. This process was first used with considerable success by Professor W. H. Pickering at the temporary station of the Harvard Observatory on Mount Wilson in 1889. Professor Pickering secured fairly good enlarged images of Saturn and excellent ones of Jupiter at that time with the 13-inch Boyden telescope and a positive eyepiece to enlarge the image. The real advance in planetary photography, however, is due to Lampland at the Lowell Observatory, who has succeeded in making excellent enlarged photographs of the planets—especially of Mars. Similar work has also been carried out at Mount Wilson by Professor Hale and at the Yerkes Observatory. I think undoubtedly that this class of work, which is of the very highest importance, is going to see its greatest perfection with the reflecting telescope—especially with reflecting telescopes of relatively great focal length supplemented by secondary enlarging mirrors and lenses.

Astronomers with visual telescopes are greatly indebted to color filter photography, as adapted by Ritchey at the Yerkes Observatory to ordinary refractors, which from their nature were not intended for photography. The splendid photographs of the Moon and of the star clusters made by him with the 40-inch telescope were a great advance over earlier work with regular photographic telescopes This simple application of the color filter and the isochromatic plate has made the 40-inch telescope one of the most important instruments for the determination of the distances of the fixed stars. Photographic parallax work was first done with it by Dr. Frank Schlesinger, who showed the remarkable accuracy that could be obtained by this method. This work with the same instrument has since been carried on successively by Fox, Slocum and Mitchell. Dr. Lee, in conjunction with Professor Van Biesbroeck, is prosecuting this work at the Yerkes Observatory with the greatest success. Van Maanen has also shown that parallax determinations made with the great 5-foot reflector of the Solar Observatory at Mount Wilson (a regular photographic telescope) are of the very highest accuracy. Astronomers now know quite accurately the distances of a large number of the fixed stars. In this way we find that it is not always the brightest stars that are nearest to us. A considerable percentage of the nearest stars are not visible to the naked eye.

There are perhaps (if we leave out the work of the spectroscope) no astronomical subjects that have been so vastly benefitted by photography as the nebulae and comets—the comets and the nebulae, which at times look so much alike and at other times are so wonderfully different, and which have no relationship in reality. Indeed half the life of the Dearborn Observatory would cover most of this class of work. The brighter nebulae were pretty well known before this, through the labors of Lord Rosse and others. Nor have we gained much in this line with the great visual telescopes that have come later. This can be said even more emphatically with respect to the comets. It is hardly too much to say that the bigger the telescope the less we have learned about these latter bodies. The comets and the nebulae were two subjects that the eye and the telescope alone could not do a great deal with, especially as the eye was not ordinarily supplemented by a skilled hand to draw what was actually seen. In reality the observer got much pleasure from his work, but he was not able, from the lack of artistic skill, to transmit what he saw to others. Furthermore, his eye lacked the power of seeing certain kinds of light in which the nebulae and comets were specially rich. He did not see all that was to be seen. In this perplexed condition there was given to him another eye that could not only see what he saw but much more, for it was especially sensitive to that other light with which the comets and the nebulae partly shine, and which combined with this power of seeing, a hand more skillful than that of any artist that ever lived. This was the photographic plate.

But let us separate these two subjects for a time and deal with them independently. Our common interpreter for both is the photographic plate.

The ordinary photographic plate is sensitive to a region of the spectrum to which the eye is almost blind. Many of the nebulae shine mostly with this light and thus the photograph has a great advantage over the eye, for though seen but dimly they are bright to the photographic plate. Furthermore, the eye becomes wearied after long gazing and one cannot see more by looking longer. The reverse of this holds with the sensitive plate—the longer it looks the more it sees, for its action is cumulative and it may be given many hours exposure, bringing into view, successively, fainter portions of the object. Thus faint nebulosities whose light could never affect the eye, are finally shown as a clear and accurate picture which can be preserved and studied years afterwards for the detection of changes in these bodies. The photographic telescope, especially the portrait lens, has a very much larger field of view than the visual telescope, which is a very important factor in the study of the nebulae or comets and of the Milky Way. Vast masses of diffused and faint nebulous matter, covering large areas of the sky are thus revealed. Much of this is too feebly luminous for the human eye ever to see. Some of this obscure matter appears to be nearer to us than the distant stars, for it obscures their light. There are other masses of it that seem to be entirely devoid of light whose presence is only known by the blotting out of the light of the stars in their direction. These feeble and widely extended nebulosities are found more especially in connection with the Milky Way. Some of the individual stars of the Pleiades are centers of condensation of what appears to be nebulous matter, and all that region of the sky is covered with streaky masses of feeble light. Are these great beds of luminous matter really gaseous? The spectroscope in recent years has thrown much doubt on some of it, though there are many of them whose gaseous condition it confirms.

We used to think of these nebulae as being at vast distances from us, much beyond the limits of our universe of stars. Photography has shown in many ways that though their distances must be great indeed, they are often well this side of the more distant stars, and that many of them—perhaps most of them—are within our stellar system, and are no farther away than some of the brighter stars.

In looking at the nebulae (such, for instance, as the great nebula of Orion) and at photographs of them, one is impressed with a sense of supreme quiet, where changes must be slow and majestic. But this serene condition would seem to be only apparent. Astronomers have found with the spectroscope that in reality the great nebula of Orion is a seething mass of gaseous matter where there is no rest and over whose vast bulk relative motions of several miles a second are constantly taking place.* But the eye, after careful years of watching, sees no change in the face of this sublime object. Thus we had come to the conclusion finally that the nebulæ would not change perceptibly in the lifetime of an individual, and this in general seems to be true, but very recently Mr. E. P. Hubble of the Yerkes Observatory has found remarkable changes in the form of another, but insignificant nebula, N.G.C. 2261. This object is the finest example of the comet-like nebulae that exists. The change in its form shown by the photographs is real and the interval required to show it is only half a dozen years. This change in the form of a nebula seems to be unique and is very important.

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* This was long suspected by Vogel, and was proved by Fabry and Buisson by interferometer methods. It has recently been fully confirmed by Frost with the spectrograph.

Add to these facts the enormous radial velocities observed in some of these bodies—especially in the spiral nebulæ,—where motions of the order of a thousand kilometers per second have been found by Slipher and others—and we begin to look upon these objects with an awakened interest that is almost sensational.

If these evidences of change stir our emotions, what must we say of the comets where utter transformations may take place in a few hours time? These bodies, always mysterious, are sometimes the source of wonderful activity. Their stay with us is short and their period of activity is shorter still. Very few comets develop a tail and fewer still become visible to the naked eye. Bright comets are, therefore, always welcome visitors. They are even more remarkable than the nebulae in their preference for the photographic plate. A comet not visible to the naked eye, and which even in the telescope is faint and shows no tail, may present to the sensitive plate a long and elaborate tail full of structure and rapid changes. It may even discard that tail, which can be followed for days by photography as it drifts away, with a speed of many miles a second, and finally dissipates in space. In dealing with comets visually there is not only the lack of artistic skill in drawing what the observer sees—since accurate measurement with respect to a comet's tail as seen with the naked eye is not possible—but there is the further fact that he is blind to much of the light that some comets emit. There are really two sources of light in a comet. One is sunlight reflected to us, the other is light emitted by the comet itself. It is this last light which is peculiarly photographic and which must actuate all the changes in the features of a comet. Halley's comet, at its return in 1910 was in some respects a source of disappointment, though a beautiful and wonderful object to the naked eye. When it once became active, it presented few changes or peculiarities to the photographic plate, and there was little learned from it that would advance our knowledge of the physical condition of these bodies. But only two years before the advent of Halley's comet there appeared a small one (Morehouse's of 1908) which in the telescope was a rather insignificant affair, and which was only feebly visible to the naked eye for about one day. This object has given us a greater knowledge of the physical condition of these bodies than all other comets that have appeared. The photographic plate was especially sensitive to its ight, while the eye was not. A bewildering amount of structure was shown in its tail, which was frequently twisted and distorted in its rapid changes. Several times the tail was discarded and new ones formed in a few hours' time. All of these remarkable peculiarities would have been wholly unknown had it not been for the photographic plate. Through the information thus gained from this comet and others that preceded it we have learned that though comets are dependent on the Sun for most of their activity, they really take a larger part in the formation of the tail and the direction of the streamers than we had previously given them credit for. These photographs show that perhaps electrical conditions have much to do with the phenomena of a comet's tail. They also suggest that other forces are at work in the inter-planetary spaces than gravity alone.

Photography offers a ready means of determining the brightness of vast numbers of stars. But since the eye is sensitive to yellow and the photographic plate to blue light, and the stars are of all colors, large discrepancies are often found in comparing photographs of the stars with the sky. It is, however, possible to reconcile these differences and Professor Parkhurst of the Yerkes Observatory and other astronomers are at present engaged in the important task of this reconciliation. Photographic magnitudes can, therefore, now be made strictly comparable with the visual.

Stebbins with his selenium photometer and others with photo-electric devices have been able to measure incredibly small changes in the light of the stars. Even the heat of the stars has been measured by Nichols and others by the delicate methods of research employed today.

Time forbids an account of the remarkable investigations of Kapteyn on the star streams of the sky. His work gives us an insight into the makeup of our stellar universe that is new and impressive, and of the utmost importance.

(*To be continued.*)

THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

[*Continued from page 440.*]

But the most important result of Scheiner's years of patient observation was the determination of the elements of the sun's rotation. The determination of these elements had been the final aim of his labors; and that he was overwhelmingly successful can readily be learned by comparing his results laboriously obtained by crude instruments and methods with the results obtained by modern methods and instruments 270 years later. Galileo had stated his belief in the sun's rotation as early as October 1611; but as we have seen, the idea of rotation of the sun was for a long time intolerable to Scheiner, who through his peripateticism was constrained to the consideration of the "Rose of the Orsini" as *corpus durum et invariable*, and only relinquished this idea when writing the *Rosa Ursina*, acknowledging the correctness of Galileo's views. But, if long denying the sun's rotation, after he once became convinced, Scheiner's many observations and careful, painstaking methods of investigation enabled him to determine with notable accuracy the elements of this rotation. These elements are: the inclination of the sun's axis to the plane of the ecliptic; the period of rotation; and the longitude of the ascending node on the ecliptic.

The first of these—the inclination of the sun's axis—was considered by Scheiner to be the most important of the three, and the most difficult of determination. He writes:*

> The determination and accurate knowledge of this quantity is one of the most important and weighty points of the whole phenomenon. Hence I directed all my energy to it, to make a fundamental determination of it, and to reach a well established truth. But I found......sometimes 6°, and so far as I know never less; sometimes 8°, but never more; but most of the time I found 7° or 7½°. On this account I have taken 7° to be the usual value. However, I do not consider this question settled, nor am I unwilling to agree if anyone finds another value, but I do not believe that this will happen. For half a degree makes no perceptible difference in this solar phenomenon, as I have indicated in numerous instances...... Hence I have taken 7° for the mean value, but also because I more often found 7°, and chiefly because I have used extraordinary care in the investigation. Moreover, I suppose that each variation or over estimate is due to some other cause, of which I will speak later.

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* *Ibid.* p. 554 et seq.

Concerning the cause of these variations from the mean Scheiner remarks:[*]

> Because, on account of their continual change of size and their individual movements, the spots readily deviate in one direction or another from their path, and hence the curvature of this path may be increased or decreased, and this increases or decreases the inclination by a small amount. This might also happen through local motions or displacements or activity in the spot itself.... .But this does not in any way influence the underlying regularity of the sun's motion itself.

Scheiner's value of the inclination of the sun's axis to the plane of the ecliptic as determined in 1630 is 7°. Comparing this result with those found by later observers; Carrington's value is 7° 15′; Spoerer's value is 6° 57′; the mean of these is 7° 6′, which is in close agreement with Scheiner's value.

Galileo made no mention of the inclination of the sun's axis previous to the publication of the *Dialogues* in 1632, apparently believing it to be perpendicular to the plane of the ecliptic. The *Rosa Ursina* was published two years before; in it Scheiner calls attention, as we have seen, to this "error" of omission by Galileo. We recall Galileo's rage on seeing this, as expressed in the letter to Fulgenzio Micanzio of February 9, 1636.[†] In this letter Galileo claimed to have been the first to discover this element of the sun's rotation, but as he himself states he neglected to make any announcement of it. It is extremely probable that Galileo must have been aware of this inclination before he saw it mentioned in the *Rosa Ursina*, for the consequences of this inclination—the changing positions of the paths of the sun-spots as they crossed the disk—furnished him with one of his strongest arguments in supporting the Copernican theory. And Galileo had stated his belief in this long before the date of appearance of the *Rosa Ursina*. If Galileo was aware of this inclination, he evidently made no attempt to determine its value, satisfying himself with the assurance of its actual existence; while to Scheiner belongs the credit for determining its value with accuracy.

The second element of the sun's rotation—the longitude of the ascending node—was entirely neglected by Galileo. In determining this, Scheiner proceeded somewhat as follows: He perceived that the period of the apparent motion of the sun's pole was one year—very obvious according to the Copernican theory—and proceeded to describe the methods by which this could be explained according to the Tychonic system. He then came to the question; what instant should be assumed as the time of beginning of this apparent motion; that is, when will the earth be in the line of nodes? Scheiner first mentions[‡] the difficulties encountered in determining this instant, in which the paths of the spots across the sun appear as straight lines. This determination is embarassed by the fact that the conditions under which the spots describe apparently linear paths last for some time, which also holds true for the times of maximum curvature of these paths.

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[*] *Ibid.* p. 557.

[†] *Gal. Op.* **16**, 391.

[‡] *Rosa Ursina*, p. 558.

> Since this thing presents difficulties from all sides, but on the other hand as it is one of the most important points [of the solar theory], I have tried to solve it by every possible means, and have investigated it with all important facts......After a great deal of labor, I have found as one can say......that the south pole of the sun reaches the periphery of the visible solar disk at about the first of December, or perhaps the 28th of November......

From this Scheiner deduced "about" 69½° as the most probable value for the longitude of the node. Reduced to the present epoch this value becomes 73°.1 in close agreement with Carrington's value of 74°.5, and Spoerer's value of 75°.7. Considering the crudeness of the instruments, and the practical difficulties of the method, the value deduced by Scheiner is certainly an excellent one.

The period of rotation was deduced from the apparent paths of such spots as were suitable for the purpose. Scheiner noted the time required by these in travelling from the eastern to the western limb of the sun, in order to ascertain from it the angular velocity of their motion, having due regard of course for the inclination of the sun's axis. The period was also obtained from observation of the successive reappearances of certain spots. The value finally deduced, of 27 days for the synodic period* he regarded as only approximate, "for many more years of observation and better instruments are needed." From 27 days, a value of 25.3 days is deduced for the sidereal period, in close agreement with Carrington's period of 25.38 days in general use at present.

These accurate determinations of the elements of the sun's rotation are the greatest fruits of the years of patient toil which Scheiner devoted to accumulating his observations; and in truth, after 280 years our modern values show little change. When one remembers the crude apparatus at Scheiner's disposal, and the limited range of the methods of mathematical analysis at that time, one must freely yield to him all praise for careful and accurate observing.

Scheiner naturally attempted to formulate a theory which might in some measure explain the causes of the transformations which he observed continually taking place on the surface of the sun. But in this he was quite conservative, restraining himself from assertions which could not be supported by the observations. He wisely devoted himself to observing, and in this he was pre-eminently successful, surpassing all others before him, and indeed many since his time. That Scheiner refrained from extensive theorizing was undoubtedly due to his subservience to tradition, and to the deficiencies of the sciences of physics and chemistry which he clearly recognized. Nevertheless, it is true that in the *Rosa Ursina* Scheiner did to a certain extent break away from the accepted and traditional explanation of natural phenomena, but it was necessary that he should either do this or deny the evidence of his own senses. But in fear of giving offense to his religious colleagues he dared not advocate these unconventionalities too strongly. Consequently he collected, with untiring patience, endless quotations from the Church Fathers regarding the nature of the heavens and stars, to show that his views did not conflict with the established doctrines of the Church. One sees with pity, how, arrayed one after the other, the views deduced from the previously conceived notions of such men as Chrysostum, Gregory of Nyssa, Anastasius, Augustine, Bonaventura, Origen, Ambrose, Hilarius, Justin the Martyr, and hosts of others, of absolutely no value whatever for the purpose, are employed to defend and justify those things, the certainty of which had already been proven by the observations. But Scheiner's subservience to the spirit of the times will not disparge him in our eyes, if we but transport ourselves to a similar position in that time of strife and discord, in which the newly conceived views of nature were still engaged in a conflict with the established traditions of the Aristotelian School.

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* *Ibid.* p. 601.

Independent of the fact that the sun was no longer the "unspotted eye of the world," which could be denied by no one who looked through a telescope, Scheiner no longer held to the older view that the sun was a solid body throughout. He now conceived that the sun, at least that portion of it in which the ever changing phenomena were observed, was gaseous or fluid and in a fiery or glowing condition. It appears that he conceived of a layer or stratum similar in many respects to what we have called the photosphere. The spots, he believed, were solid bodies which swam or floated or were immersed in the fluid stratum, often rising to its surface like bubbles. The changes that here took place Scheiner believed resulted from "extraordinary increase and decrease of density," or at least this was the cause of the difference of level. One recalls his statement, "the nucleus is more dense than the penumbra, which in turn is more dense than the faculae;" and the remark concerning the "immersion" of the nucleus, as of a dense body floating in a less dense medium.* However, there is naturally much in his views that is vague and obscure; but today, even after 280 years, it cannot be said that the present solar theories are wholly satisfactory even as far as the known facts are concerned.

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* Just why a more dense body should float in a less dense medium is not apparent.

The interior of the sun is little more accessible to us than it was to Scheiner, nor can we say that our knowledge is much more complete. It is certain that Scheiner did not consider the interior cold, dark and habitable as did Herschel; nor does it appear that he considered it a rigid body. He considered not only the outermost visible surface of the sun, but the whole body of it as a place of tremendous convulsions, the effects of which were to be seen in the spots, faculae and granulation. Scheiner emphasizes the fact that the phenomena which we observe have their origin not outside of, but within the body of the sun; the ultimate causes of all the great changes and transformations visible on the surface, must be sought for in the interior of the sun. To explain the phenomena:

> ......one must recourse to inner occurrences, so that whatever may be the substance which causes the formation of the spots, it is driven from the interior of the sun itself, through local condensations, with the accompaniment of many changes to the surface......The mutual repulsion of the spots, which occurs during the course of growth, and the attractions, which would otherwise be difficult to explain, all testify to this.[*]

It concerns him at this place to state also that the spots do not originate through the annexation of any material which may be exterior to the sun, but are formed from the material of the sun itself.

Scheiner opposed the objections which were advanced against the assumption of a burning sun. The objection that such a condition should have resulted in some visible effect, he dismisses with the remark that with such an argument one could oppose every hypothesis of whose truth one is not yet convinced. He adds[†] that since its creation, the earth has undergone enormous changes; one needs only to think of the gigantic glaciers which descend into the valleys, yet the Alps remain mountains and the valleys remain valleys. In a similar manner the sea makes great changes in the land, but if these changes were to be viewed from a distance they would be unnoticed. How then, can we notice the gradual changes in the sun? Scheiner believed that in spite of the great changes that take place, the sun as a whole remains essentially the same, that there is no combustion and that nothing is lost.[‡] As an illustration he mentions water, which may be transformed into vapor by heat, and then by cooling transformed into water again, without loss of material. Also charcoal dust, which is very inflammable, when enclosed in an airtight container can be "exposed to the most intense heat for days and days without loss of material." Hence, if the sun is incandescent, it by no means follows that it is consumed.

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[*] *Ibid.* p. 493.

[†] *Ibid.* p. 654.

[‡] *Ibid.* p. 655.

Concerning the interior of the sun, Scheiner expressed himself in an equally unconventional manner. He does not hesitate not only to assume that the fluid condition at the surface extends far into the interior, but also considered different rotation periods at different depths a possibility. Naturally he confesses that this is rather a "startling idea," and apologizes that he has forsaken his custom and advanced an "elegant theory" which he can neither prove nor disprove. But with a spirit more in sympathy with the sciences of his day, he questions whether the interior of the sun might not rotate in 24 hours, which would be in "beautiful accord" with the 24 hour terrestrial day! That the faculae and spots did not conform to this, is ascribed to their "individual peculiarities."

Scheiner also credited the sun with a luminous atmosphere which wholly surrounded it, and floated above the region of the spots and faculae. The phenomena of certain spots which appeared with very dark nuclei at the center of the disk, but show much paler and fainter at the limb, are explained by this; Scheiner stating that the difference is a result of the different length of path traversed by the light rays. It is unfortunate that Scheiner did not perceive that the phenomenon of the darkening of the sun's limb could also be explained by this atmosphere. He believed that the sun became brighter and purer as one progressed inwards from the surface, and the limb appeared dark in consequence of the brighter central portion.

It is perhaps outside the subject, but it is interesting to note that Scheiner evidently had little faith in Astrology. He considered that the spots and faculae were simply the surface manifestations of deeper lying processes, and could not believe that these gigantic upheavals were entirely without effect on the earth.[*]

> If the astrologers ascribe many things to the aspects and conjunctions of the planets, and to eclipses, what should one think concerning the phenomena of the sun, frequently covered with 50 or 60 spots,......the enormous faculae,.......and sometimes uniformly bright and tranquil without any of these? Naturally common sense demands that all this should affect the earth, and bring about various results,...... for all these things increase or decrease the light of the sun itself.[†]
>
> From the phenomena of the sun is most clearly shown the falsity of astrology... for if the sun is found in a state of continual change, the influences of the stars must be altered also. But the condition of the atmosphere, to which the astrologers give little or no heed, dishonors their ridiculous rules, which are derived from the aspects and influences of the various planets.

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[*] *Ibid.* p. 601.

[†] *Ibid.* p. 604.

It is to be noted that the reasons for terrestrial disturbances produced by the sun, were considered by Scheiner in the broadest manner. To the question, by what means can the sun affect the earth, he replies, that this must happen through a material force emanating from the sun. For this force he can find nothing other than "radiation" (radiosa species).

> I use this word 'radiation' as embracing not only the light, but....all other forces inherent to the sun and which emanate from it in straight lines.

These are essentially Scheiner's views of the constitution of the sun. The experience gained by many years of observation had taught him that true knowledge could be gained only through a careful and systematic study of the actual facts themselves, and that without this mere speculation was useless and vain. He clearly recognized the deficiencies of the methods of investigation then in vogue, and realized that real results were to be obtained only through new methods.

> Considered from the physical standpoint the phenomena of the heavens are to us mostly unknown, little certain, and a large part doubtful; man asserts much that is false, and denies much that is true. But what wonder,......for all this is separated from us by inconceivable distances, so that excluding the spherical forms, and a few eclipses, we know almost nothing. But now, after the invention of the telescope and its universal application, we are permitted,......not only to see, but to make conspicuous the stored up treasures of the science of the heavens.*

He voices the dawn of a new science—Astrophysics—when he remarks:

> Because the solar phenomena are at the same time astronomical and physical phenomena, indeed pre-eminently physical phenomena, their nature demands an investigation not only from the mathematical but also from the physical standpoint.

That Scheiner recognized the importance of the study of solar phenomena as a means of explaining other problems of the heavens, which at that time were still mysteries, is shown by the remark :†

> These and other questions of celestial physics arouse us to the opportunity offered by these phenomena. He, who wishes to solve them truly and correctly, without deceit or falsity, will resort to the sun, and from this will elicit better answers than from the Delphic Tripod and Apollo himself.

In other words, the sun is the only star that we can study in detail. and hence, the fundamental study of solar physics is eminently suitable to lead into the right paths our views of the nature of the other stars.

As may well be supposed the *Rosa Ursina* met with a very varied reception. Galileo and his friends were much enraged, while the

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* *Ibid.* p. 606.

† *Ibid.* p. 607.

Jesuits and other followers of Scheiner were proportionately elated. But even before the *Rosa* had appeared from the printer, news of it had spread abroad. Galileo had heard of it from various sources, and to judge by a letter written to Cesare Marsili in Bologna, was not particularly sanguine regarding its contents, for he writes:*

> I hear by accident that the unknown Apelles is printing in Bracciano a long treatise *de maculis solis*, and the fact of its being long makes me suspect that it is full of nonsense, which, by being infinite can soil many pages, while the truth will occupy little space. And I am convinced that if he will say anything except what I have already said in my solar letters, he will say all vanity and lies.

Which was certainly true as far as the first book is concerned.

The ire of Galileo and his friends was principally aroused by the presumption of Scheiner, who in the first book of the *Rosa Ursina* claimed for himself the priority of discovery, at the same time endeavoring to discredit Galileo and his work, with what Carrara calls a "just, dutiful, and legitimate defence." There can be no question that Galileo's methods of reinforcing his arguments were an example not to be emulated. His uncompromising championship of new scientific ideas, the slight respect that he showed for established and traditional authority, and the biting sarcasm with which he was so fond of greeting and squelching his opponents, won for him many enemies in scientific and philosophical circles. But this does not excuse Scheiner from the disgraceful manner in which he endeavors to enforce his own claims in the first book of his great volume, as even Carrara is finally forced to admit. Nor can we spare Scheiner the reproach of unfairness and animosity towards Galileo for his discovery and correct theory of the solar spots; and it is most singular that in the midst of this mighty, vehement polemic we read:†

> It is to be added, that never has he introduced himself as the first discoverer; in accordance with the example of Christ, and through the lesson learned in the school of humility.

How much the hypocrisy of the manner in which Scheiner wrote his defence angered the learned Italian is seen from the letter to Fulgenzio Micanzio, which has already been quoted. Nor were Galileo's friends less aroused. Benedetto Castelli, a lifelong friend and former pupil, whose language is strong if nothing else, writes to Galileo on the 26th of September 1631:‡

> As for the *Rosa Ursina*, already in Rome I saw something of it, but it appeared to me, as it really is, so stinking (puzzolento) that I do not wish to see any more of it; and then I remained too much nauseated by the poisoned rage and the

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* *Gal. Op.* **14**, 36.
† *Rosa Ursina*, p. 26.
‡ *Gal. Op.* **14**, 297.

> bestiality of the author, who ought to be corrected with something besides ink. I should think that it would be well for some friend of yours to send a printed letter to the Father General of the Jesuits, like that of Marco Guiducci, in which the said Father should be exhorted not to permit such mischevious things to be put forth, any one of which would render infamous the name of all those reverend Fathers. I have spoken with various people in Rome who have smelled of this "Rose," and they all remain very much nauseated by it. And one day in particular, there was a long and honest discussion regarding that which is put at the beginning of the book, in which is seen the most profound arrogance of the author in boasting most absurdly of his familiarity and friendliness with princes, etc. Considering this lofty ambition, it is no marvel that infuriated and beyond all reason, he has turned against you, from whom no doubt he was expecting the erection of temples and altars with incense. Then let us leave him in his nastiness and stench, and do not think of him.

In another letter written in February of the following year, Castelli writes:*

> Campioli is opposed to the idea that you should waste a single word against the German [Scheiner] who has thus spotted his own reputation rather than yours. And I for my part, do not want to see any more of it [the *Rosa Ursina*], being nauseated by the little that I did read,—full of ignorance, inflated with conceit, and poisoned with anger.

Evidently the *Rosa Ursina* did not prove to be a "best seller"; Micanzio tells us:†

> The *Rosa Ursina* is here in the bookstores. They tell me that not one of them is being sold, and in truth such a big volume inspires terror, and especially in myself, for I am very busy; nor do I know that I have ever found in big volumes anything but chaff in which there is but little grain.

However, Micanzio must have overcome his fears, for he keeps us informed in several letters of his progress through the book, and of how "little grain" he was able to find. Finally, six months later, on reaching the fourth book he writes to Galileo:‡

> I am in the fourth book of the *Rosa Ursina*; in all this farrago I do not see how I am going to discover anything except that there are spots in the sun, true and real, that they are contiguous to it, that they have a motion from the east to the west,......but all this was in the letters to Welser. It seems to me, as it is certain that each day some [spots] are created and some vanish in all portions of the solar disk, it remains very uncertain whether those which they say come back are really the same, or are others similar to them; and I form an opinion from our clouds which might have very similar appearances. In conclusion I have learned nothing

But Micanzio was in fact wrong, for the *Rosa Ursina* does contain many facts regarding the phenomena of the spots and faculae which were unknown to Galileo. However, as far as being lost in the chaff is concerned, Micanzio is certainly correct.

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* *Gal. Op.* **14**, 330.
† *Gal. Op.* **16**, 268.
‡ *Gal. Op.* **16**, 385.

Other letters might be quoted, but these will suffice to show with what energy and heat the conflict was waged. On one side, on account of the accusations and ridicule of Galileo; and on the other side by the uncalled for and boastful attempt to discredit Galileo's discoveries and his reasoning thereon. That Scheiner was not always careful in his statements is revealed by a letter of Paulus Jordanus himself, to whom the *Rosa* was so extravagantly dedicated, written December 30, 1631, possibly in reply to a letter of complaint from Galileo (which apparently has not come down to us).[*]

> There has just come to me what you write concerning the contents of the book of the *Rosa Ursina*, in which without my knowledge you have been wronged, because I would not have permitted my minister at Bracciano to publish it. And it may have happened during the absence of our Auditor General that it was examined by the Chancellor who does not understand latin well. Of the indiscretions of the author I do not marvel much, for I have already found him indiscreet in having only recently again broken faith with me.

Having seen to what extent the friends of Galileo were enraged by the publication of the *Rosa Ursina*, and the opinions to which they gave vent concerning it, it is only just to present the other side of the case and to give the views of less partial judges. Hevelius, not a Jesuit, but a Protestant, calls Scheiner:[†]

> A man of incomparable and universal erudition who, in his recently published observations, displays so much intelligence, that in this matter he snatched the palm away from everybody......Since, therefore, he has preceded us in this matter in such praiseworthy fashion, it is right for us to follow in his footsteps, and to inquire as well as we are able into all these questions most diligently.

Weidler remarks in his *Historia Astronomiae*:[‡]

> This work he has pursued with so much assiduity, wisdom, and circumspection, that he has made more than 2000 observations; and has clearly transmitted to posterity the positions, places, forms, sizes, appearances, disappearances, and durations of the spots, and from these demonstrated the monthly rotation of the sun, so that he seems to have conquered himself and the sun and posterity in desperation of any better observations.

Von Braunmühl quotes a letter[¶] from Gassendi, who was on friendly terms with both Scheiner and Galileo, in which the writer assures Scheiner of the great pleasure that the reading of the book has yielded him, that he agrees with all that is mentioned in it, and has learned much that is new. "A most sublime essence", he remarks in his blandiloquent manner, "that is exhaled from this Rose,[||] ... and a mighty eye that has beheld so many sacred mysteries."

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[*] *Gal. Op.* **14**, 322.

[†] *Selenographia seu Lunae descritio*, Gedani, 1647, p. 82.

[‡] Page 434.

[¶] *Op. Cit.* p. 65.

[||] Very different sense of smell from that of Castelli!

To come to more modern times, we quote Winnecke who, in reproving Delambre, writes:*

> Scheiner, notwithstanding his unspeakable longwindedness, by no means deserves the severe reproaches which he has so long received; this I have learned through my earlier investigations of his writings. I consider him absolutely sincere in communicating what he has seen. In his *Rosa Ursina* truths are established which, on account of the undeserved praise of earlier observations had long been forgotten, but which were soon to be rediscovered.

The chief defect from which the *Rosa Ursina* suffers, barring the perhaps unique combination of roses, bears, and sun-spots, is its unconscionable longwindedness, and the tedious style of writing which makes all of Scheiner's works so difficult of approach. But Scheiner was not alone in this, for prolixity is also found in the writings of the great Kepler. It was a fault of the times rather than of the man. But in this, as in observing the sunspots, Scheiner well outdistanced all competitors. Galileo was himself diffuse in his writings, but he understood better how to mould his ideas into a form that would draw and hold his reader, and took good heed not to give such a voluminous character to his works that the mere sight of them would frighten off the prospective reader. The great popularity of Galileo's writings can in part be traced to his unsurpassed art of exposition.

Galileo discussed nearly all the important questions which had arisen from the phenomena of the spots in his letters to Welser. The greater part of these he solved correctly; not because of a wealth of observational material, the discussion of which would confirm the truth of his deductions, but instead, through the intuitive perception always possessed by the genius. Scheiner, however, collected with astonishing zeal observation after observation, and upon this secure foundation constructed a theory, which in the majority of points was in harmony with Galileo's, and in some even surpassed it. But how much more is it to the credit of Galileo that he was able to reason correctly from so small a number of observations. It was here that his keen insight led him to recognize the true interpretation of the phenomena of the motions and appearances of the spots, while his unfettered mind, constrained by no subservience to the established doctrines of Peripateticcism, allowed him to retain and support the conclusions that he had deduced. His arguments were presented with a force and clearness, which was remarkable for those days of metaphysical fog and obscurity; and reading through the letters to Welser, one appreciates more and more the extraordinarily keen perception of this great man, who could recognize and use to its best advantage in explaining his theory each phenomenon of the spots. Scheiner's letters suffer greatly in comparison, for while the statements of observed phenomena are substantially correct, he attempted to explain them according to the impossible theories of the Peripatetics and the result, as might be expected, is a hopeless jumble of fact and incorrect theory. While deserving of all praise for his untiring industry in observing, Scheiner did not accept the truth until it had literally forced itself upon him through his many observations. Scheiner was an observer; in this he surpassed Galileo; he determined correctly more facts concerning the phenomena of the spots than did the Italian. But Galileo, thanks to the continual persecutions of his enemies, to say nothing of ill health and other domestic troubles, had small opportunity for routine observing, as had Scheiner secure in his protection under the cloak of the Jesuit Order. Never was a man so persecuted for fifty out of the seventy-eight years of a busy life as was Galileo. Hardly one of his discoveries or published opinions correct or incorrect has wanted antagonists; and as Parchappe remarks,* one must lament the loss to science in the enormous expenditure of energy and time consumed in defending himself and his teachings from the incredible rage of his enemies in struggles without end. But while one must regret the quarrels which were so costly; the discussions and controversies regarding the solar spots, as Wolf remarks in his *Geschichte der Astronomie*, were not entirely without advantage, for the spots were brought into the greatest prominence and observation of them stimulated, so that in the two principle works of the opponents, the *Istoria e Dimonstrazione* of Galileo and the ponderous *Rosa Ursina* of Scheiner we have a mass of material collected, which otherwise would doubtless never have been obtained.

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* *Vierteljahrsschrift der Astronomischen Gesellschaft*, **13**, 288.

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* *Galilee: Sa Vie, Ses Decouvertes, et Ses Traveaux*, Paris, 1866.

FOX'S MEASURES OF DOUBLE STARS.*

ERIC DOOLITTLE.

The large volume which is the subject of this review will be welcomed with an especial pleasure by all students of double stars. In the first place, it appears as Volume I, of the Annals of the Dearborn Observatory, and so forms a splendid beginning for what we may hope will prove in time a long series of publications not unworthy of the high standard set by this initial work. In the second place, it is the first extended publication of the young Director, Professor Philip Fox, and its upward of 200 pages of most careful and thorough measures are an evident testimony of his industry, perseverance and skill. Probably no one but a confirmed observer of double stars can realize what a great amount of solid, hard work is represented by a series of measures such as this; the brief notes, not unfrequently met with on the pages, which mention temperatures of 0 degrees to —19 degrees while the measures of the winter months are in progress, tell of adverse conditions only to be overcome by a true devotion and interest in this work.

It is peculiarly appropriate that this extended publication from the Dearborn Observatory should consist of measures of double stars, for from first to last the Dearborn objective has played an important role in this branch of astronomy. It will be remembered that it was with this glass, even before it had left the makers' hands, that Alvan G. Clark first saw the companion of Sirius, for which discovery he was awarded the Lalande Prize of the French Academy of Sciences. This was in 1862. From 1876 to 1880, Burnham, whose surprising discoveries with the far smaller 6-inch had already attracted wide attention, added no less than 402 new pairs with the Dearborn lens, and these discoveries were published in two volumes which also contained measures of 1270 additional pairs. And lastly, it was with this lens that all of the 649 pairs of Professor Hough were discovered.

The new volume of Professor Fox contains 229 quarto pages; on 209 of these there are found the measures themselves, the remaining pages being devoted to a brief introduction. The dedication, which all double-star observers cannot but regard as a peculiarly graceful and fitting one is as follows:—

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* Annals of the Dearborn Observatory, Northwestern University, Volume I. Measures of Double Stars, by Philip Fox. Evanston, Illinois, 1915. Pages v + 229.

To Sherburne Wesley Burnham,—whose labors brought new life to Double Star Astronomy: who spared not himself in oft heroic vigils: whose personal encouragement has been the direct inspiration for these observations, this volume is gratefully inscribed.

The introduction begins with a complete and interesting history of the Chicago Astronomical Society from the time of its origination in 1862: it tells of the purchase of the 18½-inch lens early in 1863, and of the various vicissitudes of this from that time until it finally was installed in its present location on the grounds of the Northwestern University. There then follows a full account of the determination of the zonal foci of the lens by the Hartmann test, concerning which Professor Fox says:—

"The excellence of this objective is well-establishe by the long list of difficult double stars which have been discovered and observed with it. There is no better evidence of quality than that of actual accomplishment. The application of the Hartmann test to it is therefore of peculiar interest, as the investigation constitutes not only a test of the objective, but in a way a test of the Hartmann method."

And lastly, there is described the method of making the measures of the present volume. Professor Fox uses the electric illumination, keeps the line joining the eyes either parallel or perpendicular to the wires during the measures, and makes three or more settings for double distance and four for position angle on each night. In measuring the last, he adopts, except in wide pairs, the method in use by Van Biesbroeck, Doolittle, and some other observers of separating the wires a few seconds and placing the stars between them; this differs slightly from the method of Aitken and Hussey, who use but a single wire. An examination of the measures themselves, particularly those of binary stars which have been observed on a large number of nights, shows that the results are accurate and consistent. As an approximate result from the examination of 42 pairs I find the probable error of angle to be but 0.6 degrees at a distance of 3″, and 1.3 degrees at a distance of 1″, the magnitudes being not very unequal. These are of very nearly the same size as the same quantities determined by Dr. Aitken from an examination of his own measures with the 12-inch and the 36-inch.*

The pages of measures which follow are arranged under four heads. There is first a complete re-measurement of the 171 Holden pairs, a few of which, having been discovered by Holden when on an eclipse expedition to the Caroline Island, lie so far south that they are not accessible to northern observers, and which were measured for the present publication by R. T. A. Innes. There then follows a similarly complete series of observations on the 66 pairs discovered by Kustner, at Bonn; next are 171 pages of measures on miscellaneous selected stars, and lastly the description and measurement of 52 new pairs discovered by Fox himself in the course of the present work.

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* By the term "Probable Error" is here meant the mean of the residuals, all taken with the positive sign. See Publications Lick Observatory, Vol. XII, Page VII.

These measures are throughout very carefully made,—practically no incomplete measures are included,—and the results are printed in the most concise and convenient form, the use of which was so strongly urged by Burnham but which many observers have not yet adopted. When necessary, the position of the pair is determined by identification in the DM or by measurement from a nearby DM star, and in many cases the magnitudes are estimated. In short, the work leaves nothing to be desired in the completeness and care with which it has been prepared. It should be added that Professor Fox adopts the epoch 1880.0 for all of the positions. This is a most wise choice and it is much to be desired that all double-star observers would follow this plan,—at least for many years to come and until a later, standard epoch can be agreed upon.

Most of the Holden and Kustner stars are faint pairs of about 2″ or more separation, and in but very few of these does Professor Fox find any evidence of change. But there are at least two which form remarkable and interesting exceptions. The first of these is the close pair, Holden 60, **(12696)**, a close and rather faint pair which is undoubtedly a binary in rather rapid retrograde motion. Fox's measures indicate that the two components approached to within a quarter of a second of each other in 1909, and that, while they are now separating, the motion in angle is still no less than about 10 degrees a year. Though it is too early as yet to find out much about the orbit, the system is certain to be a most interesting one and should be kept under continual observation.

The second pair,—which may prove to be of even a higher interest,—is made up of two stars as faint as the 9.5 and 10.2 magnitudes respectively. This is Kustner 47, **(6667)**; at the Flower Observatory we have had it under constant observation for the past five years and a valuable series of measures is also being made upon it by Professor Barnard. Since 1901 the angle has increased 30 degrees and the distance has changed from 1″.9 to 3″.9; the pair may prove similar to the even fainter pair Krueger 60, **(11761)**, (which, as Barnard has shown, is undoubtedly a binary, and the faintest wide binary known in the heavens), or the observed change may be due only to the proper motion of one of the stars. Upon the last supposition, Fox finds the amount of this proper motion to be 0″.18 annually.

The measures of the Holden and Kustner stars are followed by measures on some 1200 selected pairs and these make up by far the greater part of the volume. A very brief examination suffices to show that the pairs have been carefully and wisely chosen. There is hardly a pair on which measures were not needed at this time, and a large proportion of them have been measured but once or twice previously or else almost wholly neglected. On these pages are also included measures on 63 pairs which had not been previously noticed as double by other observers but in which the components were regarded by Fox as too far separated to justify their inclusion in the list of new double stars. Upon comparing these with my manuscript catalogue which forms the extension of Burnham's General Catalogue, I find only one which has been measured elsewhere. This one is DM + 43° (12), (Page 54), which will be found also registered as AB of Espin 1406; but although Espin's measure was published first, the measure by Fox antedates it by no less than six years. Beside the component measured by Fox there is a 14 magnitude companion, discovered by Espin, 4″.9 from B.

Lastly we have the 52 new pairs discovered by Fox himself. By comparison with the manuscript catalogue, the following notes are suggested on these and on the other new pairs.

Page 93. DM −12° (1281). The R. A. is 14s too great.
p 112. 10-2-30. It is the position of the DM star that is here given.
p 125. The R. A. is 5s too small (12-21-9).
p 157. 17-3-10. The Decl. is 1′.5 too large.
p 164. CPD=Cord. DM −27° (12259).
p 178. 19-4-27. The R. A. is 14s too great.
p 211. + 10° (4831). The identification differs from that in the G.C.
p 222. The R. A. is 1 min. too small. (23-57-45).
Fox 6. The R. A. is 11s too small and the Decl. is 3′ too small. No DM star is in Fox's position.
Fox 7. The R.A. is 2 min. 4s too small. No DM star in the place given.
Fox 8. The Decl. is 20′ too large. This pair is undoubtedly identical with Jonckheere 340.
Fox 17. The Decl. is 3′.5 too small.
Fox 19. This is called Fox 10 by prior observers.
Fox 24. = Cord. DM −24° (13823)
Fox 30. The identification here disagrees with that of the G.C.
Fox 32. First seen by Aitken, but only a few months before Fox's discovery. This is Aitken 2278.
Fox 39. CE of Fox is DE of Aitken 2095. Aitken finds that A is also a very close double. The companion called D

by Fox seems to be new. It is quite remarkable that Aitken did not notice this with the 36-inch in 1909.

Fox 40. This is registered as Espin 1439, but it was first seen double by Fox.

Fox 45. = Cord. DM −23° (17319).

Fox 47. The Decl. is 5′.4 too small.

In the list of new pairs there are several which will probably prove of future interest. Fox 22, (0″.71), and Fox 32, (0″.53), are especially noteworthy, and the greater proportion range from 1″ to 3″ in distance. The new pairs are on the whole faint, but it is hardly to be expected, after the careful surveys of Aitken and Hussey, that anything more than an occasional new discovery will be made among the brighter stars except by observers with instruments of the very largest apertures.

Altogether this new volume is an excellent example of patient, conscientious and accurate observing. It is precisely work of this nature that is now most needed to advance our knowledge, and these results of Professor Fox, representing as they do the outcome of some six or eight years of labor, form a most valuable contribution to this end. All double-star observers will add to the congratulations which they extend to him the hope that he may long devote himself to this most useful field of work.

The Flower Observatory,
July 22, 1916.

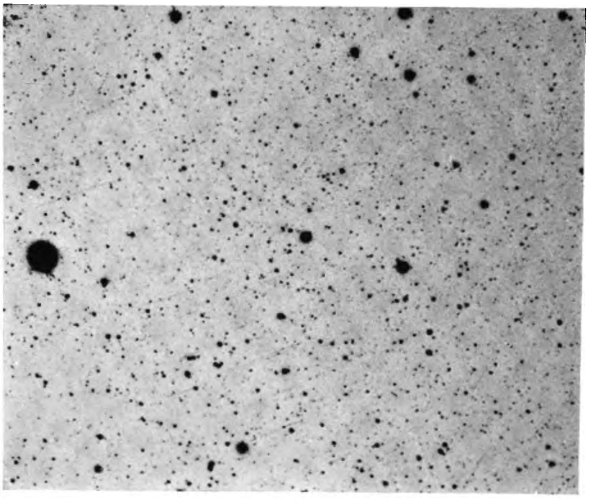
A SMALL STAR WITH LARGE PROPER MOTION.

E. E. BARNARD.

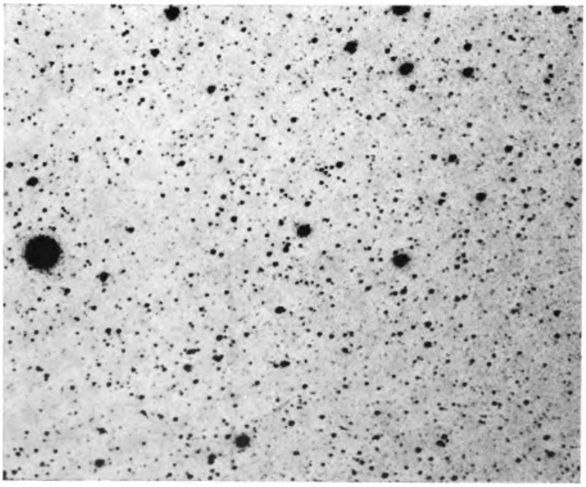
When comparing two of my star plates made, respectively, with the 6-inch Willard lens of the Lick Observatory, 1894 August 24, and with the 6-inch Bruce lens of the Yerkes Observatory, 1916 May 30, in the Zeiss blink comparator, I found (on the new plate) an 11th magnitude star which seemed to have left no trace on the 1894 plate. At first it was supposed that this might be a nova as the place fell in the Milky Way. I also found, nearly 4′ south of it, what appeared to be a variable star which was bright on the Lick plate and faint on the new one. On examining another plate made 1904 June 11 there seemed to be

PLATE XXIX

NORTH



Made with the 6-inch Willard lens of the Lick Observatory, 1894, August 24.



Made with the 6-inch Bruce lens of the Yerkes Observatory 1916, May 30.

PHOTOGRAPHS OF THE REGION ABOUT THE SMALL STAR WITH LARGE PROPER MOTION another variable star which was bright on the 1904 plate and faint on the plates of 1894 and 1916. The presence of several variable stars so close together raised suspicions, and on comparing the different plates it was found that all the images were on a straight line. It would seem then that the bright images must all belong to the same object which on two of the dates accidentally fell on a faint star image and gave the impression of several variable stars. A comparison with a plate taken 1907 April 20 showed that this was so (for the image on that plate did not correspond with any on the other plates) and that the different photographs could be reconciled by supposing the different images to have been made by a star with an annual proper motion of about 10″. This supposition has been verified, especially as Professor Pickering finds the star on the Harvard College Observatory plates as far back as 1888 and 1890. See H. C. O. Bulletin 613.

The star, which we will call *P*, is not in any known catalogue or star list, but it is shown on Plate 53, Publications of the Lick Observatory, Vol. XI. It is 1.77 inches (45^{mm}) from the right side and 2.64 inches (67^{mm}) from the top of that plate, south following BD + 4°3560, which is Albany A. G. C. 6005, and which in this paper is called *a*. The position of the star at present is:

$$\text{Epoch } 1916.423 \quad \alpha\ 17^h\ 53^m\ 43^s.60, \quad \delta + 4^\circ\ 27'\ 48''.0$$

It is $9^s.1$ following and 51″ north of BD + 4°3560.

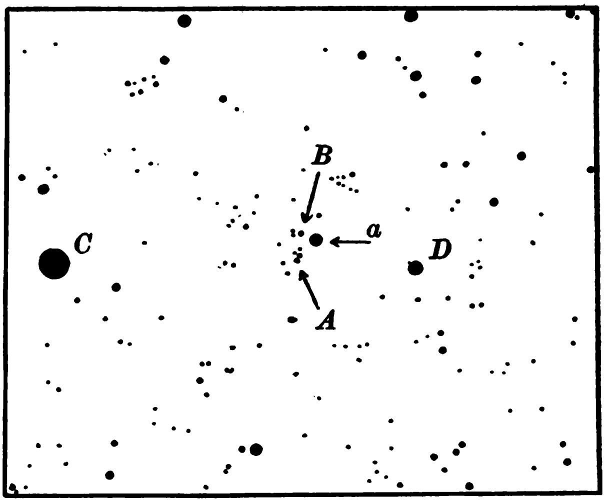


Diagram Showing the Position of the Small Star with Large Proper Motion on the Photographs of 1894 August 24 and 1916 May 30.

A = Position of *P* (Proper Motion Star) 1894 Aug. 24.
B = Position of *P* 1916 May 30.
a = BD + 4°3560 ($8^m.7$).
C = BD + 4°3570 ($5^m.3$).
D = BD + 4°3556 ($8^m.0$).

As this object, from its large motion, is likely to become of general interest, I have prepared the accompanying plates, by the aid of which it may readily be found in the sky and followed for many years to come. To avoid defacing the pictures by marking on them, the diagram is given to locate the star on the photographs of 1894 and 1916. I have also added a third photograph made with the 40-inch refractor with a yellow color filter and a Cramer Isochromatic plate. This photograph will be specially interesting to amateurs, because, by comparing it with the sky, they can readily identify the star and see its rapid motion in a few months time. A second diagram is also given which was made from the micrometer measures and is directly comparable with the 40-inch photograph.

The present measures made with the 40-inch telescope compared with those from the photograph of 1894 give the annual motion 10″.3 in the direction 359°.7, so that the star is moving almost directly north. This is the largest apparent stellar motion known.

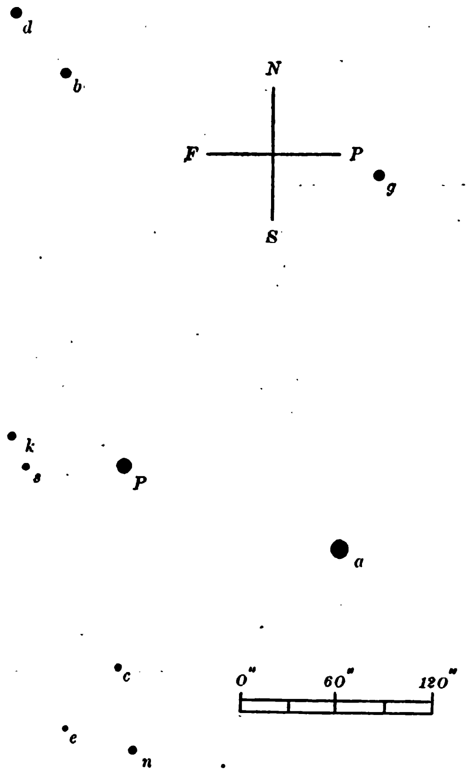


Diagram Showing the Stars Measured with Respect to the Proper Motion Star, *P*. Epoch 1916.5.

PLATE XXX

PHOTOGRAPH OF THE FIELD OF THE SMALL STAR WITH LARGE PROPER MOTION

Made with the 40-inch Refractor and Yellow Color Screen 1916, June 14. Exposure 51^{m}. Scale 1″ = 0.008 in. = 0.019 cm. The two bright stars are ***P*** (to the left) and BD. + 4° 3560 (to the right).

The star is yellowish—especially when contrasted with the near-by star BD + 4°3560, which is bluish white. This difference of color is very marked in the portrait lens photographs, where the BD star is many times larger than *P*. In the photograph with the color filter the two differ very little in size, because *P* gets the effect of the full value of its light, while *a*, being blue, loses some of its light by absorption with the yellow filter. Visually, *P* is at least one magnitude less than the BD star, and is hence about the 10th magnitude.

In the photograph with the 40-inch the large images are of *P* (to the left) and *a* (to the right). The small stars *k* and *s*, which are scarcely separate on the portrait lens photographs, are widely separated on this plate.

Following is a list of the micrometer measures of the position of *P* with respect to some of the surrounding stars, from which the diagram was constructed.

		P.A.	Dist.	Mag.	Mag.	Obsns.
		°	″			
P and *a*	1916·465	249.03	145.19			(6*n*)
P and *b*	1916.507	8.79	250.16	— —	12.1	(3*n*)
P and *c*	1916.477	178.35	126.74	— —	13.5	(8*n*)
P and *k*	1916.483	75.18	72.44	— —	12.9	(6*n*)
P and *n*	1916.485	181.86	179.34	— —	13	(5*n*)
a and *c*	1916.471	118.33	158.20			(2*n*)
a and *k*	1916.467	70.99	217.07			(2*n*)
a and *n*	1916.482	134.00	183.83			(3*n*)
k and *s*	1916.482	203.67	21.21	12.8	13.5	(2*n*)
b and *d*	1916.538	42.38	48.01	12	12¼	(1*n*)

The stars *e* and *g* have not been measured micrometrically and are introduced on the diagram, by estimation, for the sake of completeness.

Mr. Adams at Mount Wilson finds the following facts about the star from his spectroscopic observations.

Type of spectrum	Mb (Harvard classification)
Radial velocity	— 91 km
Parallax from spectrum	+ 0″.2

This spectrum is characteristic of stars with high velocities and is known as the "dwarf" type of M type stars.

If we combine the above parallax and radial velocity with the proper motion we find the star's true motion in space to be 161 miles (260 km) per second. From the above parallax the distance would be 16.3 light years.

This object is in the northern part of the constellation of Ophiuchus and is thus fortunately well placed for observation at all observatories. It has been put on the parallax list of the Yerkes, and other observatories.

Following is a list of previously known stars with annual proper motions larger than $5''$, which is taken from Kapteyn's list of "Stellar Parallaxes and Proper Motions," in the Appendix to Young's Manual of Astronomy.

Name	α 1900	δ 1900	Mag.	Proper Motion
	h m	° ″		″
Cordoba Z. V. 243	5 07.7	—44 59	8.5	8.70
Groombridge 1830	11 47.2	+38 26	6.6	7.05
61 Cygni	21 02.4	+38 15	6.1	5.16
Lacaille 9352	22 59.4	—36 26	7.1	7.00

To this can be added *P*, with annual proper motion of $10''$.

The star 1830 Groombridge, as will be remembered, is the celebrated "Runaway Star."

In "The Observatory" for April 1916 it is stated that Mr. Innes has discovered a red star of the 10th visual magnitude (12 magnitude, photographic) with a proper motion of about $5''$ per annum. The position for 1900 is:

$$\alpha\ 14^{h}\ 22^{m}\ 55^{s},\quad \delta - 62^{\circ}\ 1'.6$$

Yerkes Observatory,
Williams Bay, Wisconsin.
July 25, 1916.

ADDITIONAL OBSERVATIONS.

The following additional measures of *P* have been made and are added to the proof:

		P.A.	Dist.	Obsns.
		°	″	
P and *a*	1916.641	248.38	145.05	(11*n*)
P and *b*	1916.617	8.78	249.27	(5*n*)
P and *c*	1916.649	177.91	128.40	(8*n*)
P and *k*	1916.641	76.67	72.72	(11*n*)
P and *n*	1916.641	180.76	180.80	(4*n*)
P and *g*	1916.599	319.19	237.83	(3*n*)
k and *s*	1916.587	203.59	21.09	(1*n*)
b and *d*	1916.576	42.22	48.93	(1*n*)
g and *t*[*]	1916.576	337.63	63.58	(1*n*)

The motion of *P* given in the above paper depends upon the position from the Lick photograph of 1894. The image on that plate is confused with that of another star. It is away from the center of the field, and is not very good to measure. The amount of the annual motion needs, therefore to be verified by better observations. I have tried to do this from the present micrometer measures of *P* and *c* (which latter star lies close to the line of motion). The measures so far obtained, using four of the first and four of the last observations, give for the annual motion $9''.8$, but this depends upon an interval of only 0.22 of a year.

September 20, 1916.

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[*] Not on diagram.

INVISIBLE COMETS.

WILLIAM H. PICKERING.

The nucleus of a comet may be defined as that portion of a meteor swarm which gives out sufficient gas to become electrically luminous. Often there is no nucleus, only a general illumination. It does not necessarily include the whole swarm, since swarms are often elongated, and comets' heads are usually spherical. The escaping gases, certainly in the case of large comets, often reach far beyond the limits of the swarm. Sometimes the swarm has two or more nuclei, and sometimes several swarms follow along in nearly the same orbit.

A meteor swarm, on the other hand, may be defined as a comet which strikes the earth. Fortunately, within historic times these swarms have all been invisible until they entered our atmosphere, otherwise they would doubtless have occasioned great and general distress and alarm. In the Harvard Bulletin 608, Professor Perrine records the appearance on May 4 of this year of a bright object, which between 9^h and 10^h moved 10° towards the Sun's place. He suggests that it may possibly have been a comet. If so, it must have been a very small one, and situated very near the earth. In POPULAR ASTRONOMY, 1909, 17, 330, it is shown that we probably strike the head of a luminous comet once in about every 2,000,000 years. It is possible that collisions occur rather more frequently than that, but since it is probable that life has existed upon this earth for at least 100,000,000 years, and perhaps longer, it would seem that we must have been in collision with fully 50 luminous comets during that interval, with evidently no very serious results in consequence, hitherto. On the page above referred to in the tenth line, by a typographical error one zero was omitted, and the number should have read 1,000,000,000.

Many short period comets have ceased to be luminous during the past century, sometimes lighting up again temporarily after a long series of years. Unless shifted into another orbit, and driven out of the solar system altogether, these innumerable invisible comets, like derelicts at sea, must still be pursuing their way amongst us unannounced, and gradually disintegrating. Whether their returns to perihelion exceed those of the visible comets 10, 100, or 1000 times, we have no means of knowing, but astronomically speaking, collisions with them cannot be rare.

The heads of the smaller comets that we usually see are in general of about the size of the planet Jupiter, but there seems to be no theoretical lower limit, and it is possible that the meteor swarms themselves are sometimes only a few miles in diameter. The latest instance of this sort is that of the brilliant meteoric display which became visible in western Canada on the night of February 9, 1913, and was traced across Canada and some of the Northern states, past Bermuda, and was last seen off the South American coast, in longitude 33° 30′ W latitude −3° 20′ S, a total course of some 6000 miles. (Journ. B. A. A. 1916, **26**, 275.) This display must have been due to a graze with a very small swarm, moving in a direct orbit, which had passed perihelion, and which reached its descending node at the earth's orbit a little too late for a direct collision. Nevertheless, it had a few of its outlying members dragged down into our atmosphere to a sufficient depth to become self-luminous, and to be ultimately destroyed and captured. Different members were constantly being dragged in along the whole route. If the main mass escaped, as seems probable from Professor Chant's account of the phenomenon, (Journ. Royal Astron. Soc. of Canada, 1913, 7, 157, 444,) its period of revolution will have been materially shortened, and other returns will occur in the future at intervals, upon the same night of the year. That the display was of such small dimensions, only three or four miles in width, would imply a very minute swarm. That none of the meteors reached the earth's surface confirms the computed value of their high velocity, and the fact that they have not since been seen, shows that they were, and are still, if not destroyed, revolving about the Sun, and not about the earth as a primary.

It is recorded in Chambers' Astronomy 616, that at Cairo in August 1029 "many stars passed, with a great noise, and brilliant light." If this report is correct, the phenomenon observed must have been similar to that above recorded, and described so fully by Professor Chant. The loud noise heard in both cases differentiates them clearly from an ordinary Perseid, or even the finest Leonid display. These showers are silent because their orbits are retrograde, and the individual meteors are therefore burned up in the upper layers of the earth's atmosphere. In no other early record of meteoric showers is there mention of any noise being heard. It is unfortunate that we have no record of the direction of motion of the Egyptian meteors, but it is probable that like the Canadian display their orbit was direct.

Another small swarm of meteors which struck the earth very recently was the Leonid shower which fell on the night of November 14, 1901. The first relatively modern observation of the Leonid display was made in 1698. As pointed out in Popular Astronomy, 1899, **7**, 523, since that date it has appeared with considerable regularity in multiples of 34 years. Its next appearance was 101 years later in 1799. Its finest modern appearance was in 1833. It appeared next in England in 1866, and in the States in 1867 and 1868. There is evidence that the last was the finest shower of the three, but these observations are little known outside of the Eastern States. Taking 1867 as the mean date, the next year on which a shower should have been expected, adding another 34 years, was 1901, not 1899 as assumed by Messrs. Stoney and Downing, and in 1901 a small but fine shower appeared, as we shall presently see. Since in their investigation these computers used an erroneous period, placing the shower fully two years out of the way, some doubt may well be felt as to whether their conclusion that, owing to perturbations when passing near Jupiter, the meteoric orbit now lies 100,000 miles inside that of the earth at the node, is justified.

The great shower of 1799 was observed throughout the whole extent of the American continent, and was even seen in Greenland, but since then the areas have been much more restricted, that of 1833 reaching only from the great Lakes to somewhat north of the equator, and the more recent showers covered still smaller areas. Since the whole earth must pass through the geometrical plane of the meteoric orbit within a few minutes of time, it is singular that in the same longitude a shower should not, with clear skies, be equally visible throughout a great range of latitude. Yet such is by no means the case, and hitherto no satisfactory explanation of it has been offered.

In 1866 Dawes with a single assistant counted the meteors at the rate of 1200 per hour, which for a single observer would mean perhaps 800 in that period. In 1901 with perfectly clear skies in Cambridge, in latitude +42°, we counted the meteors at the rate of 60 per hour for a single individual, yet on the steamer Admiral Dewey, latitude +26°, in the same longitude as Cambridge, and at the same time, they appeared at the rate of over 420 per hour. At Trinidad, B. W. I., the rate was 290; at Fort Worth, Texas, 420; Sonora, Mexico, countless; Tucson, Arizona, 225; Claremont, California, 800 for four observers, or presumably 400 for one. At the Lowe Observatory, California, the rate was 300. The shower does not appear to have been quite as pronounced as that of 1866 in England, but even in Cambridge the rate was twice that of any previous year. Most of the stations where many meteors were observed were near latitude +30°. Six observers were at work in Cambridge, but 60 an hour was the best rate that anyone secured. Other northern observers obtained similar results. The next important display should occur in 1935.

Mandeville, Jamaica. B. W. I.
August 4, 1916.

KARL SCHWARZSCHILD.*

The war exacts its heavy roll of human life, and science is not spared. On our side we have not forgotten the loss of the physicist Moseley, at the threshold of a great career; now, from the enemy, comes news of the death of Schwarzschild in the prime of his powers. His end is a sad story of long suffering from a terrible illness contracted in the field, borne with great courage and patience. The world loses an astronomer of exceptional genius, who was one of the leaders in recent advances both in observational methods and theoretical researches.

Karl Schwarzschild was born on October 9, 1873. His mathematical ability developed with almost precocious rapidity. His first scientific papers, relating to the theory of determining orbits from observations, were published in the *Astronomische Nachrichten* in 1890; they show such wide reading, combined with original insight that it seems almost incredible that the author was a schoolboy of sixteen. On taking his university course, he studied at first at Strasburg under Becker, and afterwards at Munich. There he came under the inspiration of Seeliger's teaching, which apparently was the basis of his later researches on stellar statistics; he often expressed regret that the work of Seeliger was so little understood in other countries. His career after leaving the university is divided into three stages:—he was at first assistant in the von Küffner Observatory, Vienna; in 1901 he became Professor and Director of the Observatory at Göttingen; finally in 1909 he succeeded Vogel as Director of the Astrophysical Observatory, Potsdam.

Schwarzschild's researches were amazingly varied. He was a master of almost all branches of physical and mathematical science. It is difficult to pick out any one work as his special title to eminence; for it was not his way to write exhaustive memoirs—to wring his subject dry. He made his contribution—some clearcut theorem marking a definite advance, which others might follow up and harry out in detail —and then he passed on to some new point on which his genius could throw light.

In practical astronomy perhaps his chief work was his determination of photographic magnitudes. This was one of his earliest researches, being started at Vienna and developed at Göttingen. His method was to draw out the star-image into a uniform patch of light, of which the density or greyness could be measured in order to ascertain the brightness; this spreading out of the image was accomplished partly by displacing it out of focus and partly by making it travel in a definite manner over an area of the plate. With the coöperation of his assistants at Göttingen, he compiled in this way the "Göttingen Aktinometrie," a catalogue of photographic magnitudes of stars between Dec. 0° and +20° down to the limit $7^{m}.5$, reduced to an absolute scale. This work brought out very clearly the close relation between the colour and spectral type of a star, and also the fact that it is the stars of intermediate colour—the yellow stars—which have the largest proper motions.

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* This account of the life of Schwarzschild is taken from "The Observatory". Though unsigned the identity of its English author may well be guessed.

In this connection it may be mentioned that Schwarzschild was the first to employ a coarse grating in front of a telescope object-glass—a plan which is now often used both for determining photographic magnitudes and measuring star colour. Schwarzschild, however, did not apply it to these purposes, but measured the separations of double stars with it, using it as a kind of double-image micrometer; he varied the distance between the two images by inclining the grating at different angles to the axis of the telescope. The method does not seem to have been tried on a large scale, though the experiments with a small telescope gave good results.

To Schwarzschild we owe the theory of radiative equilibrium of the Sun. It seems probable that this theory represents the observed phenomena better than any other; but, like much of Schwarzschild's theoretical work, the value lies not so much in the correctness of the physical assumptions as in the clear formulation of the problem, enabling us to appreciate the possible alternatives and the manner in which they affect the solution. His great step was to recognise that there are three types of equilibrium of the Sun's atmosphere according as conduction, convection, or radiation is the most effective in transferring heat. By working out the last alternative he brought the theory into fit state to be compared with observation, and the value of this would have been none the less great even if observation had been far less favourable to the radiative hypothesis than was actually the case.

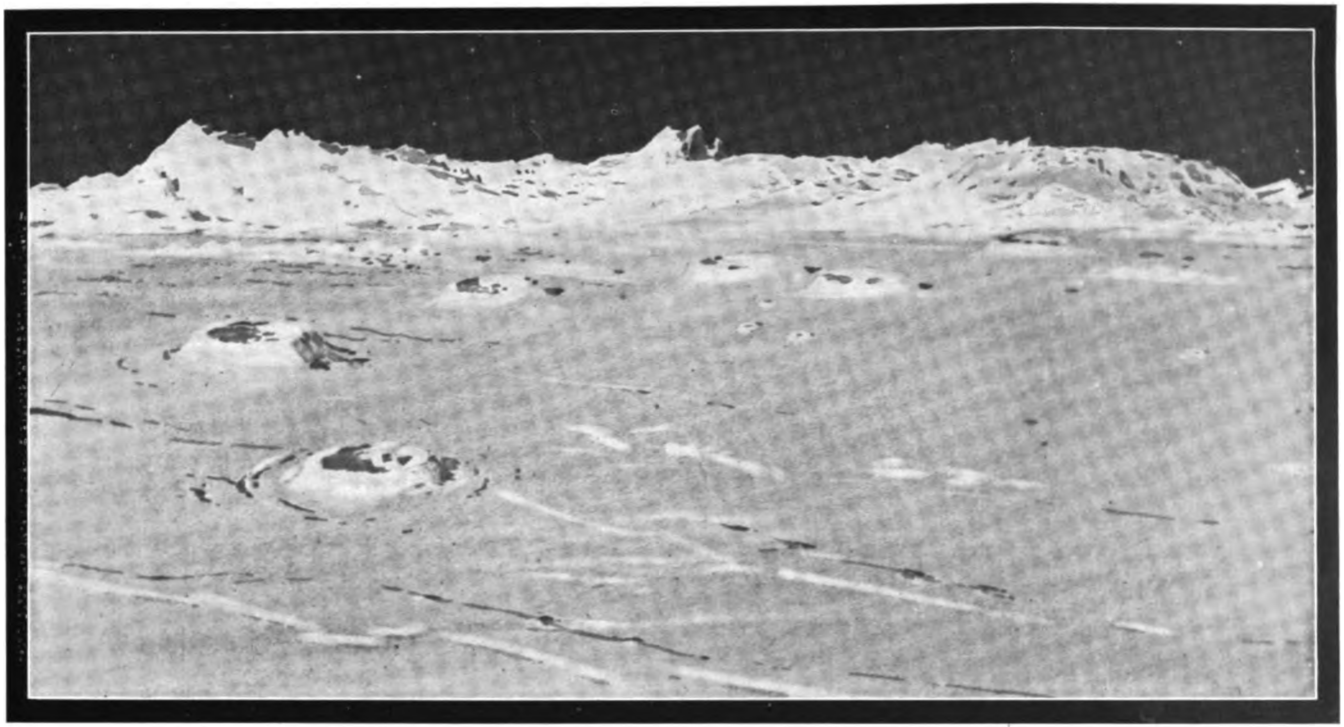
Another important result was his calculation of the pressure of radiation on small solid particles—of much interest in connection with the repulsion of the tails of comets by the Sun. For moderately large particles sunlight exerts a pressure proportional to the cross-section, whereas the force of the Sun's gravitation is proportional to the cubical contents. It follows that as the size of the particle decreases the light-pressure decreases less rapidly than the gravitation, so that ultimately the former predominates and the particle is repelled from the Sun. But the repulsion does not increase indefinitely, because, when the size of the particle becomes comparable with the wave-length of light, diffraction takes place. For a very small particle the light-waves bend round instead of being stopped. There is thus a certain size of particle for which the repulsion is a maximum, and Schwarzschild calculated that this upper limit is about 19 times the solar attraction. In view of the fact that the repulsive forces observed in comets' tails are sometimes considerably greater than this, this limit to the efficacy of light-pressure is of great interest.

In stellar statistics Schwarzschild's best known work was his ellipsoidal hypothesis of stellar motions. Kapteyn had in 1904-5 published a summary of his celebrated investigation which showed that there are two streams of stars. In later work, for the purpose of precise mathematical treatment, it had seemed best to take the two streams quite literally, and represent the motions as due to two independent systems of stars passing through one another. Schwarzschild, however, proposed a mathematical treatment of the phenomena, which retained the essential unity of the system; the double streaming was, of course, duly represented in his formulæ, but he avoided any suggestion that it arose from the encounter of two clusters. The ellipsoidal hypothesis is a most elegant piece of mathematics, and is specially adapted to simplify many of the problems of stellar motions which have arisen. Without it much of the recent progross would have been impossible. It is characteristic of Schwarzschild that his whole work on this subject, which has had so great an influence on stellar investigation, is contained in two papers of 28 pages in all. He made many contributions to other branches of stellar investigation which are too technical to be described here; but it may be mentioned that his general solution of the integral equation of stellar statistics appears to be not only of astronomical value but a noteworthy contribution to pure mathematics.

Professor Baker, in the last number of the *Observatory*, brought to light the almost forgotten fact that an important point in the theory of exchange of stabilities in dynamics is due to Schwarzschild. Outside astronomy, his papers ranged over geometrical optics, electrical theory, thermodynamics, and the navigation of balloons. His last work was a paper on the Quantum Theory published by the Berlin Academy of Sciences; he corrected the proofs on his sick-bed.

Schwarzschild's characteristics were not those which are usually associated with the scientists of his nation. Keen and restless, his nature was remote from the slow plodding German character. He was a most enthusiastic mountaineer, and had accomplished some of the most desperate ascents in the Alps. He was full of the adventurous spirit, in winter sports in Switzerland, in early Zeppelin ascents—and in the last great adventure of all. His writings are a model of clear-

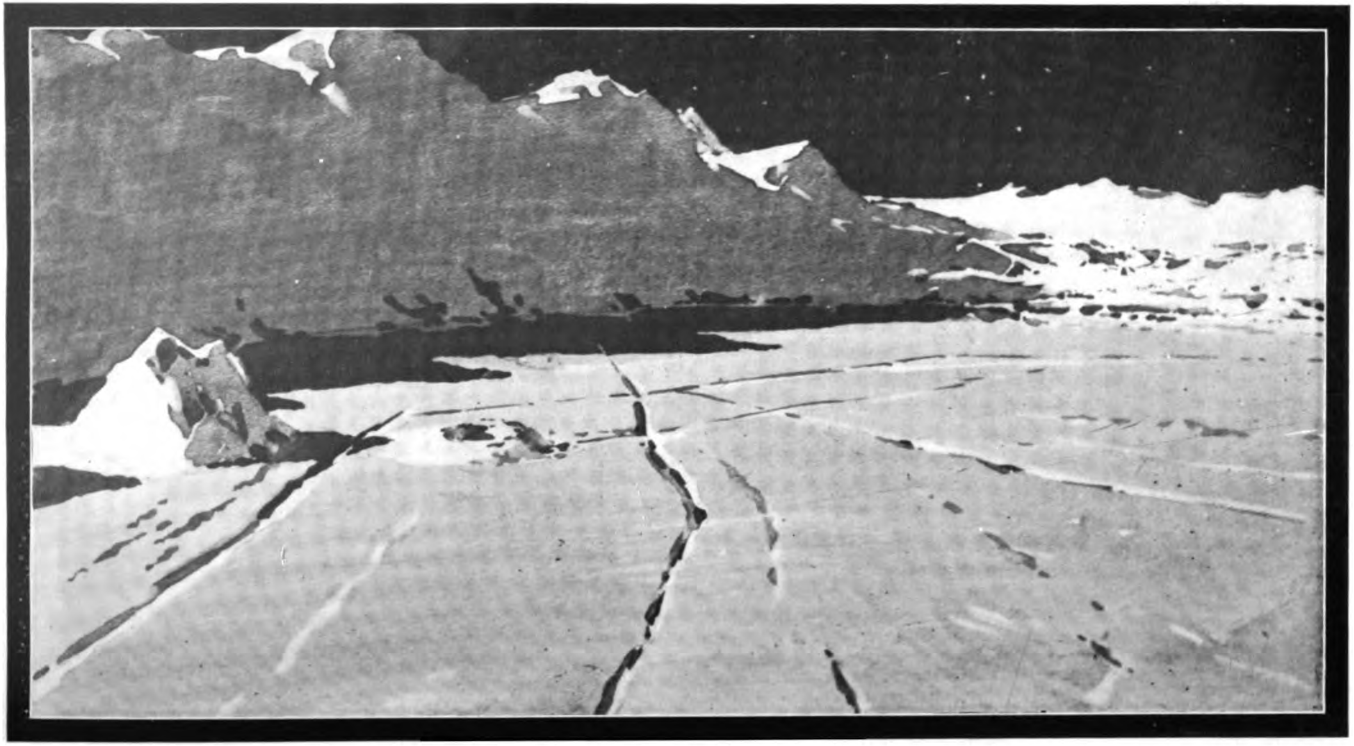
PLATE XXXI



APPROACH TO GASSENDI FROM THE MARE NUBIUM

A Moonscape drawn by Russell W. Porter, "Land's End" Observatory, Port Clyde, Maine.

PLATE XXXII



THE FLOOR OF GASSENDI, LOOKING SOUTH
A Moonscape drawn by Russell W. Porter.

ness and concise expression; he never inflicts on us the unbalanced detail and the mazes of analysis—the penalty of "German thoroughness"—which render so many German scientific writings unattractive. He goes straight to his point without any unnecessary sentence. It would be paving an ill-service to the memory of one who gave the final proof of devotion to his country, to seek by these traits to dissociate him from the rest of his nation. We would rather say that through him a new spirit was arising in German astronomy from within, raising, broadening and humanizing its outlook; and we are confident that he has left behind an influence which will enlarge and revivify the old traditions.

MOONSCAPES.

RUSSELL W. PORTER.

Astronomy, often considered the noblest of sciences, is usually viewed by the layman as an unbearably dry subject, and too rigorously exact to stir his imagination. This assumption is far from the truth. No sphere of research today offers more boundless fields of conjecture than the study of the heavens, aided by modern methods and instruments.

Our nearest neighbor, the moon, is a case in point. The writer, in viewing her surface through his sixteen inch reflector in the comfort of a closed observing room, has frequently caught himself transported to that body, and, in imagination, viewing her scenery from some crater lip or the vast expanse of one of her sea floors. Having himself spent many years above the Arctic Circle, he was struck by a strange likeness of the moon's general aspect to our own polar regions. The long reaches of the frozen polar ocean, traversed by immense pressure ridges and tidal cracks, the dazzling whiteness and clear cut shadows, the desolation and loneliness—all seemed to find a counterpart in the lunar appearance. The accompanying moonscapes were the natural outcome.

No great accuracy is claimed in their presentation. In fact they may be considered very much as flights of fancy, although the main feature and heights were plotted by the rules of perspective. The height of the eye has been assumed arbitrarily, as well as the direction and height of the sun. It is possible that, from one of the greater elevations, the curve of the horizon, or bulge of the moon, would be appreciable. And we are quite sure that it would cut sharp and clear against an intensely black sky.

One inevitable conclusion, at any rate, is always reached, after a prolonged journey over the ghastly whiteness of the moon's surface, and that is a more just appreciation of our own atmosphere, with its softening envelope of tints and haze, clouds and color.

"Lands' End" Observatory.
Port Clyde, Maine.
June 1916.

PLANET NOTES FOR NOVEMBER, 1916.

The sun will follow a south-easterly course through the constellation of Libra into Scorpio. At the end of the month it will be north of Antares.

The phases of the moon for November are as follows:

				h m	
First Quarter	Nov.	2	at	11 50.6 A.M.	C.S.T.
Full Moon		9	"	2 18.0 P.M.	"
Last Quarter		17	"	4 0.5 P.M.	"
New Moon		25	"	2 50.4 A.M.	"

The moon will be at apogee on November 15 and at perigee on November 27.

Mercury at the beginning of the month will appear in the morning sky before sunrise. It will gradually approach the sun and on November 23 will pass superior conjunction. During the month its motion will be in an eastward direction in the constellation of Virgo.

Venus will be the bright morning star of the month. Its magnitude on November 15 will be —3.5, exceeding the brightness of Sirius by almost 2 magnitudes. At this time about three fourths of the entire disk will be illuminated. On November 20 it will be near the brightest star in Virgo, Spica. Its actual distance from the sun is decreasing. On the eleventh of November it will pass perihelion. Since the orbit has such a low eccentricity (0.0068), perihelion passage does not have the significance that it has in the planetary orbits which are more eccentric.

Mars will be visible low in the western sky during the month. It will move eastward from the constellation of Scorpio into Ophiuchus. On November 1 it may be found 4° due north of Antares. It will be too low in the west to be in a favorable position for observing.

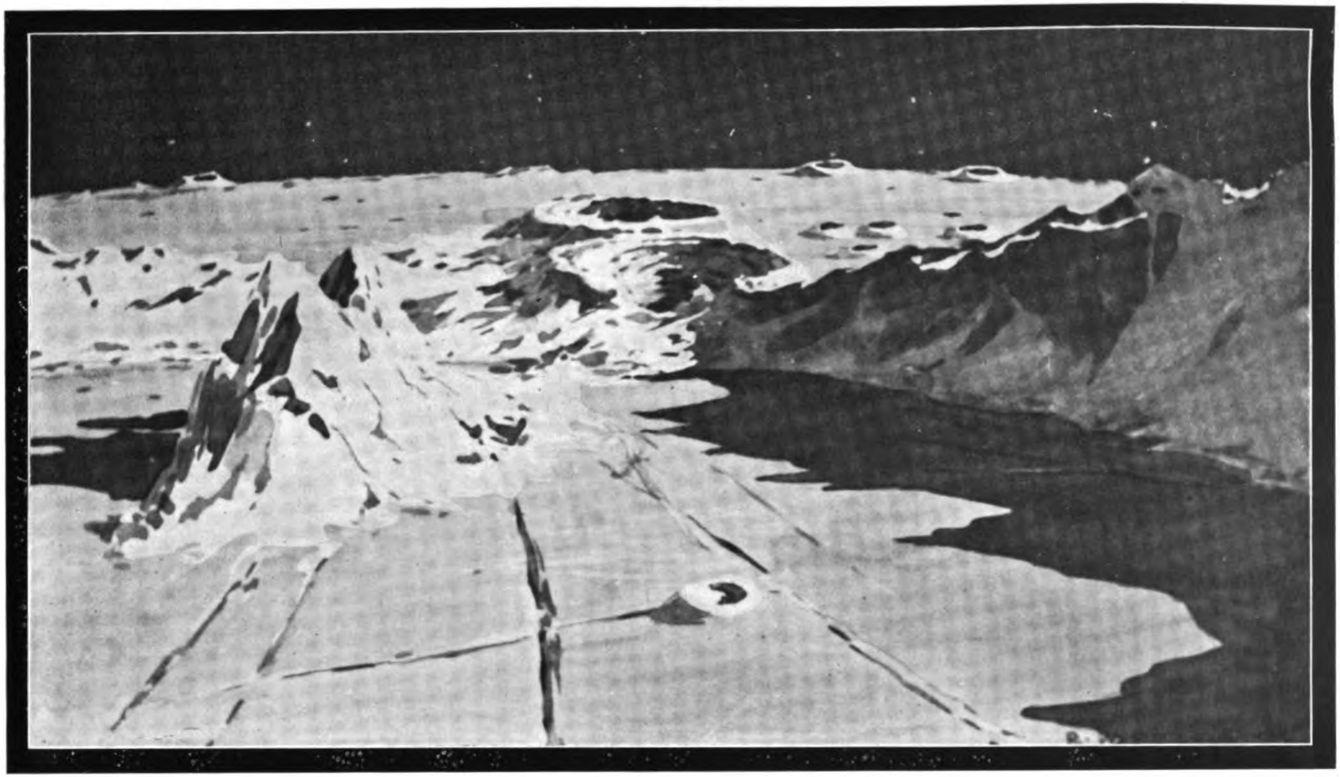
Jupiter having passed opposition on October 23, will be in a splendid position for observation during the month. Its motion will be towards the east in the constellation of Pisces. On November 15 it will reach the meridian at about 11 o'clock. A diagram of the position of Jupiter's satellites for each day of the month is given on page 518.

Saturn will be in a better position for evening observation, rising shortly before midnight. It will be found in the constellation of Cancer.

Uranus will be seen in the constellation of Capricornus. It will be well situated for observation in the early evening with the telescope.

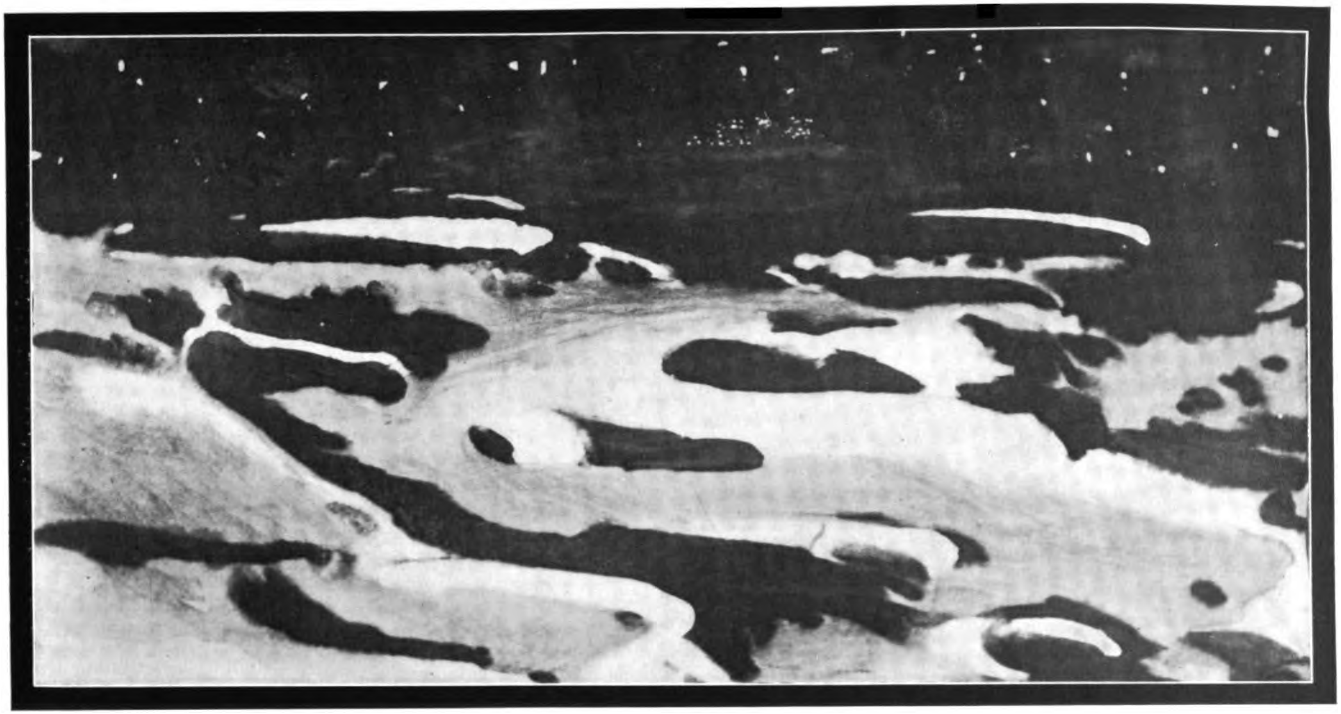
Neptune will be just a little east of Saturn in the constellation of Cancer but, of course, is too faint to be seen without a telescope.

PLATE XXXIII



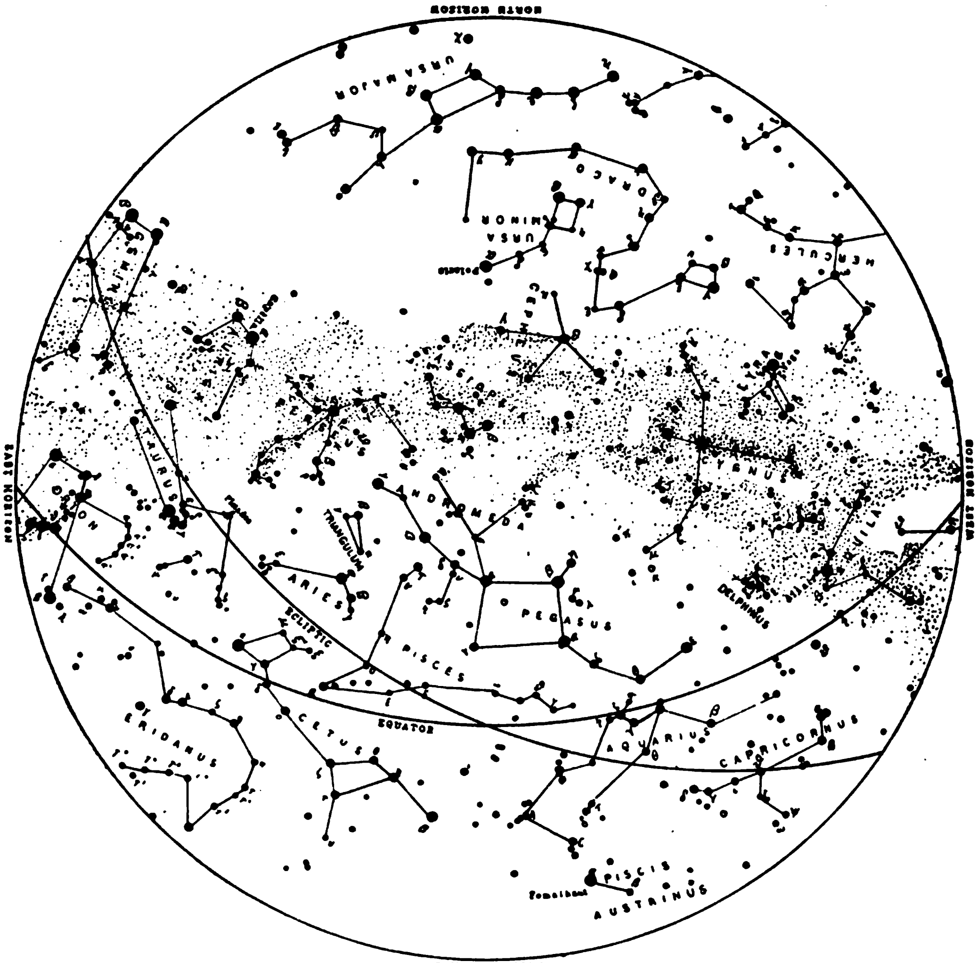
LOOKING NORTH OUT OF GASSENDI
A Moonscape drawn by Russell W. Porter.

PLATE XXXIV



REGION AROUND ROST
A Moonscape drawn by Russell W. Porter.

POPULAR ASTRONOMY, No. 238.



THE CONSTELLATIONS AT 9:00 P. M. NOVEMBER 1.

Occultations Visible at Washington.

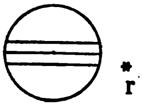
Date 1916	Star's Name	Magnitude	IMMERSION. Washington M.T.		Angle f'm N.	EMERSION. Washington M.T.		Angle f'm N.	Duration	
			h	m	°	h	m	°	h	m
Nov. 4	6 G Piscium	6.2	11	48	4	12	26	292	0	38
6	136 B Piscium	6.5	12	54	115	13	37	193	0	43
8	20 H¹ Arietis	6.4	3	37	112	4	13	204	0	36
8	26 Arietis	6.2	16	22	7	16	41	330	0	20
9	66 Arietis	6.1	17	38	111	18	31	241	0	53
10	36 Tauri	5.6	6	30	68	7	27	258	0	57
11	k Tauri	5.6	5	56	92	6	47	248	0	51
13	87 B Gemin.	5.8	8	44	58	9	33	304	0	50
14	85 Gemin.	5.2	17	6	148	18	24	266	1	15
16	ξ Leonis	5.1	19	12	158	20	22	274	1	10

Satellites of Jupiter, November, 1916.

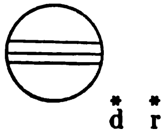
GREENWICH MEAN TIME.

Phases of the Eclipses of the Satellites for an Inverting Telescope.

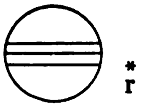
I.



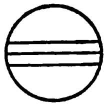
III.



II.



IV. No Eclipse



Configurations at 15h 25m for an Inverting Telescope.

Day	West		East
1	.3,2	○	1. .4
2	.1	○	.3 .2 .4
3	○1. 2	○	. .3 .4
4	.2	○	.1 3. .4
5	1. 3	○	..2 4.
6	3.	○	.12. 4.
7	.3 .1 2.	○	4.
8	.3.2	○	4.1.
9	4. .1	○	.3 .2
10	4.	○	1.2. .3
11	4. 2.	○	3. .1●
12	4. 1.	○	3. .2●
13	.4 3.	○	.1 2.
14	.4 3. 1.2.	○	
15	.4 .3.2	○	1.
16	.4.1	○	.3 .2
17		○	1. .42. .3
18	2.	○	.43. .1●
19	1..	○	2 3. .4
20	3.	○	.1 2. .4
21	3. 1.2.	○	4.
22	.3.1	○	.1 4.
23	.1	○ 3.	.2 4.
24		○	1.2. 4. .3
25	2. .1	○ 4.	.3
26	○1. 4. .2	○	3.
27	4. 3.	○	.1 .2
28	4. 3. 1. 2.	○	
29	4. .3 .2	○	.1
30	.4 .1 .	○	3 .2

Phenomena of Jupiter's Satellites.

[Visible at Washington.]

CENTRAL STANDARD TIME.

	h	m		
Nov. 1	13	50	I	Tr. I.
	14	4	I	Sh. I.
	15	58	II	Oc. D.
	15	58	I	Tr. E.
	16	13	I	Sh. E.
2	11	4	I	Oc. D.
	13	21	I	Ec. R.
3	8	15	I	Tr. I.
	8	32	I	Sh. I.
	10	24	I	Tr. E.
	10	42	II	Tr, I.
	10	42	II	Sh. E.
	11	16	II	Sh. I.
	13	13	II	Tr. E.
	13	51	II	Sh. E,
	5	30	I	Oc, D.
4	8	0	I	Ec, R.
5	4	50	I	Tr. E.
	5	4	II	Oc. D.
	5	11	I	Sh. E,
	8	16	II	Ec. R.
	11	9	III	Tr. I,
	12	18	III	Sh. I.
	12	25	III	Tr. E,
	14	5	III	Sh. E,
8	15	33	I	Tr. I.
9	12	49	I	Oc. D.
	15	26	I	Ec. R.
10	9	59	I	Tr. I.
	10	27	I	Sh, I.
	12	8	I	Tr. E.
	12	37	I	Sh. E.
	12	58	II	Tr. I.
	13	54	II	Sh. I.
	15	30	II	Tr, E.
11	7	15	I	Oc. D.
	9	55	I	Ec. R.
12	4	56	I	Sh. I,
	6	34	I	Tr. E.
	7	5	I	Sh. E.
	7	18	II	Oc. D.
	10	52	II	Ec. R.
	14	24	III	Tr. I,
	4	38	II	Tr. E.
	5	48	II	Sh. E.
16	5	26	III	Oc. R.
	6	17	III	Ec. D.
	8	4	III	Ec. R.
	11	34	I	Oc. D.
17	11	46	I	Tr. I.
	12	22	I	Sh. I.
	13	53	I	Tr. E.
	14	31	I	Sh. E.
18	9	0	I	Oc. D.
	11	50	I	Ec. R.
19	6	11	I	Tr. I.
	6	51	I	Sh. I.
	8	19	I	Tr. E.
	9	0	I	Sh. E.
	9	34	II	Oc, D.
	13	28	II	Ec. R.
20	6	19	I	Ec. R.
21	4	24	II	Tr. I.
	5	52	II	Sh. I.
	6	57	II	Tr. E.
	8	26	II	Sh. E.
23	7	18	III	Oc. D.
	8	52	III	Oc. R.
	10	19	III	Ec. D.
	12	5	III	Ec. R.
24	13	30	I	Tr. I.
	14	17	I	Sh. I.
25	10	46	I	Oc. D.
	13	46	I	Ec. R.
26	7	57	I	Tr. I.
	8	46	I	Sh. I.
	10	5	I	Tr. E.
	10	55	I	Sh. E.
	11	52	II	Oc. E.
27	5	13	I	Oc. D.
	8	15	I	Ec. R.
28	4	32	I	Tr. E.
	5	24	I	Sh. E,
	6	45	II	Tr. I.
	8	30	II	Sh. I.
	9	18	II	Tr. E.
	11	4	II	Sh. E.
30	5	22	II	Ec. R.
	10	44	III	Oc. D.
	12	23	III	Oc. R.

Note:—I., denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1916 November
	h m	° ′		d h	d h d h d h d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	14 13
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	4 2; 11 18; 19 11; 27 3
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	4 11; 11 21; 19 8; 26 18
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	1 21; 9 9; 16 20; 24 8
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	7 3; 13 5; 19 8; 25 11
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	1 2; 8 6; 22 12; 29 16
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	6 22; 13 19; 20 16; 27 12
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	5 1; 12 6; 19 10; 26 14
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	9 9; 18 4; 26 22
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	5 1; 13 0; 20 22; 28 21
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	27 2
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	1 1; 12 12; 18 6; 24 0
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	3 21; 10 16; 17 11; 24 6
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	6 19; 14 16; 22 14; 30 12
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	3 19: 12 1; 20 9; 28 17
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	3 10; 11 7; 19 5; 27 2
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	11 14; 24 19
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	5 14; 15 0; 24 11
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	9 0: 21 10
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	3 15; 10 6; 16 23; 23 15
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	3 18; 9 5; 20 3; 25 14
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	3 10; 9 11; 21 12; 27 12
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	2 23; 11 15; 20 7; 28 23
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	11 2; 21 11
SV Gemin.	54.6	+24 28	9.8 – <11	4 00.2	2 20; 10 21; 18 21; 26 21
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	3 1; 8 18; 20 5; 25 23
U Columbae	6 11.2	—33 03	9.2—10.0	2 19.2	5 14; 10 5; 20 10; 26 0
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	8 8; 17 13; 25 18
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	4 14; 12 5; 19 20; 27 11
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	12 19; 25 0
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	3 9; 10 13; 17 17; 24 21
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	6 3; 15 5; 24 7
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	9 12; 18 19; 28 2
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	17 9; 27 7
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	7 14; 16 0; 24 10
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	1 2; 7 12; 20 9; 26 19
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	5 15; 12 22; 20 4; 27 11
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	7 22; 16 0; 24 3
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	6 8; 15 20; 25 7
RX Hydrae	9 00.8	— 7 52	9.1—10.5	2 6.8	6 20; 15 23; 25 2
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	6 7; 12 5; 24 2; 30 0
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	5 23; 14 10; 22 20
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	9 22; 19 5; 28 11
SS Carinae	10 54.2	—61 23	12.2—12.8	3 07.2	3 7; 9 22; 23 3; 29 17
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	9 0; 17 19; 26 14
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	3 5; 10 13; 17 21; 25 5
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	3 8; 10 3; 23 17; 30 12
RZ Centauri	12 55.6	– 64 05	8.5— 8.9	1 21.0	1 9; 8 21; 16 9; 23 21
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	2 15; 12 5; 21 19
SS Centauri	13 07.2	—63 37	8.8—10.4	2 11.5	6 9; 13 19; 21 6; 28 16
δ Librae	14 55.6	— 8 07	4.8— 6.2	2 07.9	1 16; 8 15; 22 14; 29 14

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 November							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
U Coronae	15	14.1	+32	01	7.6— 8.7	3	10.9	5	17;	12	15;	19	13;	26	10
TW Draconis		32.4	+64	14	7.3— 8.9	2	19.4	3	8;	11	19;	20	5;	28	15
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	2	8;	10	0;	17	16;	25	7
SW Ophiuchi	16	11.1	— 6	44	9.2—10.0	2	10.7	4	5;	11	13;	18	21;	26	5
SX Ophiuchi		12.6	— 6	25	10.5—11.2	2	01.5	8	13;	16	19;	25	1		
R Arae		31.1	—56	48	6.8— 7.9	4	10.2	8	5;	17	1;	25	21		
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1	5	16;	15	9;	26	10		
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	7	15;	14	11;	21	6:	28	1
U Ophiuchi		11.5	+ 1	19	6.0— 6.7	0	20.1	5	10;	13	19;	22	4;	30	14
u Herculis		13.6	+33	12	4.6— 5.4	2	01.2	5	18;	11	22;	24	5;	30	9
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	5	11;	12	16;	19	21;	27	2
RV Ophiuchi		29.8	+ 7	19	9. —12	3	16.5	1	12;	8	21;	16	6;	23	15
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	2	9;	10	13;	18	18;	26	22
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	2	19;	10	8;	17	21;	25	10
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	3	7;	10	1;	18	18;	26	12
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	3	16;	11	16;	19	16;	27	15
WX Sagittae		53.6	—17	24	9.2—10.8	2	03.1	6	5;	14	18;	23	6		
WY Sagittae	17	54.9	—23	1	9.5—10.6	4	16.0	3	8;	12	16;	22	0		
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	6	23;	17	7;	27	15		
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	7	21;	15	3;	22	9;	29	15
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	3	6;	10	3;	17	1;	23	23
RZ Scuti		21.1	— 9	15	7.4— 8.3	15	03.2			14	21;	30	0		
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	1	16;	9	23;	18	5;	26	11
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	5	23;	14	19;	23	17		
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	3	18;	12	2;	20	9;	28	16
RR Draconis		40.8	+62	34	9.3—13	2	19.9	3	9;	11	21;	20	9;	28	20
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	2	21;	9	13;	16	4;	22	20
β Lyrae		46.4	+33	15	3.4— 4.1	12	21.8			11	15;	24	13		
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	4	9;	13	22;	22	11		
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	1	12;	9	2;	16	15;	24	5
RV Lyrae		12.5	+32	15	11. —12.8	3	14.4	3	21;	11	2;	18	7;	25	11
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	2	11;	11	10;	20	9;	29	7
U Sagittae		14.4	+19	26	6.5— 9.0	3	09.1	2	6;	9	0;	15	18	22	12
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	6	19;	14	4;	21	12;	28	21
TT Lyrae		24.3	+41	30	9.3—11.6	5	05.8	1	21;	12	8;	22	20;	28	2
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	6	0;	12	13;	19	2;	25	14
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	6	16;	12	16;	24	17;	30	17
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	6	21;	13	13;	20	4;	26	19
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	3	20;	13	0;	22	3		
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	2	18;	14	5;	19	15;	28	1
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	2	2;	8	21;	22	11;	29	6
UW Cygni		19.6	+42	55	10.5—10.8	3	13	2	13;	9	11;	16	8;	23	16
V Vulpec.		32.3	+26	15	8.2—9.8	37	19.0	4	23						
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	5	2;	14	17;	24	7		
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	4	23;	14	3;	23	8		
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	3	8;	10	20;	18	8;	25	19
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	4	18;	10	15;	22	8;	28	4
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	8	4;	18	7;	28	9		
VV Cygni	21	02.3	+45	23	12.1—13.8	1	11.4	2	0;	9	9;	16	18;	24	4
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	2	16;	12	8;	22	1		
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	4	11;	12	8;	20	5;	28	2
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3			22	15				
RT Lacertae	21	57.4	+43	24	9.1—10.5	5	01.7	1	11;	11	14;	21	18		
RW Lacertae	22	40.6	+49	08	10.2—11.2	5	04.4	4	1;	14	10;	24	19;	29	23
X Lacertae	22	45.0	+55	54	8.2— 8.6	5	10.6	5	13;	11	0;	21	21;	27	8
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.3	4	9;	12	16;	20	23;	29	6
Y Piscium		29.3	+ 7	22	9.0—12.0	3	18.4	8	1;	15	14;	23	2;	30	15
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	8	16;	16	22;	25	4		

Maxima of Variable Stars of Short Period.

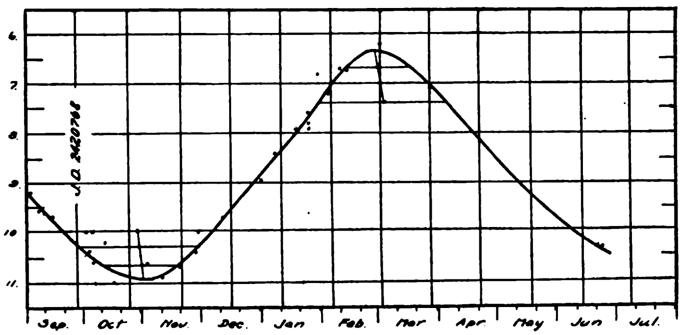
[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. November							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SX Cassiop.	0	05.5	+54	20	8.6— 9.4	36	13.7								
SY Cassiop.	0	09.8	+57	52	9.3— 9.9	4	1.7	8	16;	16	19;	24	23		
RR Ceti	1	27.0	+0	50	8.3— 9.0	0	13.3	2	5;	9	23;	17	16;	25	10
RW Cassiop.	1	30.7	+57	15	8.9—11.0	14	19.2	8	22;	23	17				
V Arietis	2	09.6	+11	46	8.3— 9.0	0	23.8	3	3;	11	1;	19	0;	26	22
SU Cassiop.	2	43.0	+68	28	6.5— 7.0	1	22.8	5	15;	13	10;	21	5;	30	0
TU Persei	3	01.8	+52	49	11.4—12.2	0	14.6	3	19;	11	2;	18	9;	25	16
RW Camelop.	3	46.2	+58	21	8.2— 9.4	16	00.0	1				17			
SX Persei	4	10.2	+41	27	10.4—11.2	4	07.0	6	15;	15	5;	23	18		
SV Persei		42.8	+42	07	8.8— 9.6	11	03.1	1	10;	12	13;	23	16		
RX Aurigae	4	54.5	+39	49	7.2— 8.1	11	15.0	7	15;	19	6;	30	21		
SX Aurigae	5	04.6	+42	02	8.0— 8.7	1	12.8	1	9;	9	1;	16	16;	24	8
SY Aurigae		05.5	+42	41	8.4— 9.5	10	03.3	10	15;	20	18;	30	21		
Y Aurigae		21.5	+42	21	8.6— 9.6	3	20.6	2	13;	10	6;	18	0;	25	17
RZ Gemin.	5	56.6	+22	15	9.1—10.0	5	12.7	3	1;	8	14;	19	5;	25	4
RS Orionis	6	16.5	+14	44	8.2— 8.9	7	13.6	4	15;	12	4;	19	18;	27	8
T Monoc.		19.8	+7	08	5.7— 6.8	27	00.3					26	20		
RZ Camelop.		23.7	+67	06	11.0—13.0	0	11.5	7	12;	14	17;	21	22;	29	2
W Gemin.		29.2	+15	24	6.7— 7.5	7	22.0	6	11;	14	9;	22	7;	30	5
ζ Gemin.	6	58.2	+20	43	3.7— 4.3	10	03.7	2	3;	12	6;	22	10		
RU Camelop.	7	10.9	+69	51	8.5— 9.8	12	06.5			15	5				
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	1	13;	9	13;	17	11;	25	10
V Carinae	8	26.7	−59	47	7.4— 8.1	6	16.7	4	21;	11	14;	18	7;	24	23
T Velorum	8	34.4	−47	01	7.6— 8.5	4	15.3	6	9;	15	15;	24	22		
V Velorum	9	19.2	−55	32	7.5— 8.2	4	08.9	7	21;	16	15;	25	8		
Z Leonis	9	46.4	+27	22	7.9— 9.6	59	0.0			20					
RR Leonis	10	02.1	+24	29	9.1-10.1	0	10.9	1	8;	8	2;	21	16;	28	11
SU Draconis	11	32.2	+67	53	8.9— 9.6	0	15.8	1	21;	8	11;	21	16;	28	7
S Muscae	12	07.4	−69	36	6.4— 7.3	9	15.8	3	1;	12	17;	22	8		
SW Draconis		12.8	+70	04	8.8— 9.6	0	13.7	5	1;	13	0;	21	0;	28	23
T Crucis		15.9	−61	44	6.8— 7.6	6	17.6	6	20;	13	13;	20	7;	27	0
R Crucis		18.1	−61	04	6.8— 7.9	5	19.8	4	15;	10	10;	22	2;	27	22
S Crucis	12	48.4	−57	53	6.5— 7.6	4	16.6	7	9;	16	18;	26	3;	30	20
W Virginis	13	20.9	−2	52	8.7—10.4	17	06.5	3	2;			20	8		
SS Hydrae		25.0	−23	08	7.4— 8.1	8	4.8	7	10;	15	14;	23	19		
RV Urs. Maj.	13	29.4	+54	31	9.2— 9.9	0	11.2	7	7;	14	7;	21	8;	28	8
ST Virginis	14	22.5	−0	27	10.3—11.4	0	09.9	5	1;	13	6;	21	11;	29	16
V Centauri		25.4	−56	27	6.4— 7.8	5	11.9	5	6;	10	18;	21	17;	27	5
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	3	3;	10	16;	18	5;	25	18
RU Bootis	14	41.5	+23	44	12.8-14.3	0	11.9	4	0;	11	10;	18	20;	26	5
R Triang. Austr.	15	10.8	−66	08	6.7— 7.4	3	09.3	1	21;	8	16;	22	5;	29	0
S Triang. Austr.	15	52.2	−63	29	6.4— 7.4	6	07.8	1	11;	7	19;	20	10;	26	18
S Normae	16	10.6	−57	39	6.6— 7.6	9	18.1	5	13;	15	7;	25	1		
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	4	6;	13	3;	21	23;	30	20
RV Scorpii	16	51.8	−33	27	6.7— 7.4	6	01.5	5	3;	11	4;	23	7;	29	9
X Sagittarii	17	41.3	−27	48	4.4— 5.0	7	00.3	1	7;	8	8;	22	8;	29	8
Y Ophiuchi		47.3	−6	07	6.1— 6.5	17	02.9	8	6			25	9		
W Sagittarii	17	58.6	−29	35	4.3— 5.1	7	14.3	7	5;	14	20;	22	10;	30	0
Y Sagittarii	18	15.5	−18	54	5.4— 6.2	5	18.6	5	10;	11	5;	22	18;	28	12
U Sagittarii		26.0	−19	12	6.5— 7.3	6	17.9	5	23;	12	17;	19	10;	26	4

Maxima of Variable Stars of Short Period—Continued.

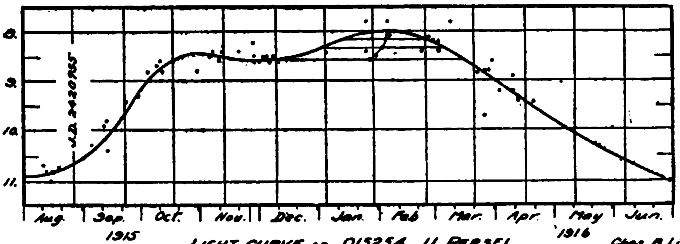
Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. November							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
Y Scuti	18	32.6	− 8	27	8.7— 9.2	10	08.3	2	0;	12	8;	22	17		
Y Lyrae		34.2	+43	52	11.3—12.3	0	12.1	3	6;	9	6;	21	8;	27	9
RZ Lyrae		39.9	+32	42	9.9—11.2	0	12.3	6	7;	12	11;	24	17;	30	20
RT Scuti		44.1	−10	30	9.1— 9.7	0	11.9	4	19;	10	18;	22	15;	28	14
κ Pavonis	18	46.6	—67	22	3.8— 5.2	9	02.2	7	7;	16	9;	25	11		
U Aquilae	19	24.0	− 7	15	6.2— 6.9	7	00.6	1	18;	8	18;	22	19;	29	20
XZ Cygni		30.4	+56	10	8.6— 9.3	0	11.2	1	4;	8	4;	22	4;	29	4
U Vulpec.		32.2	+20	07	6.5— 7.6	7	23.5	6	19;	14	19;	22	18;	30	18
SU Cygni		40.8	+29	01	6.2— 7.0	3	20.3	3	1;	10	17;	18	11;	26	4
η Aquilae		47.4	+ 0	45	3.7— 4.5	7	04.2	3	3;	10	8;	17	12;	24	16
S Sagittae		51.5	+16	22	5.6— 6.4	8	09.2	4	14;	13	0;	21	9;	29	18
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	5	8:	11	16;	24	7;	30	15
X Cygni	20	39.5	+35	14	6.0— 7.0	16	09.3			17	7				
T Vulpec.		47.2	+27	52	5.5— 6.1	4	10.5	4	23;	13	20;	22	17;	27	3
WY Cygni		52.3	+30	03	9.6—10.4	0	13.5	7	3;	13	20;	20	14;	27	7
RV Capric.		55.9	−15	37	9.2—10.1	0	10.7	6	8;	13	1;	19	18;	26	11
TX Cygni	20	56.4	+42	12	8.5— 9.7	14	17.4			12	22;	27	16		
VY Cygni	21	00.4	+39	34	8.8− 9.5	7	20.6	4	23;	12	19;	20	16;	28	13
SW Aquarii		10.2	— 0	20	9.9−10.8	0	11.0	6	24;	13	10;	20	8;	27	5
VZ Cygni	21	47.7	+42	40	8.2− 9.2	4	20.7	3	13;	13	7;	23	0;	27	22
Y Lacertae	22	05.2	+50	33	9.1− 9.6	4	07.8	3	5;	11	20;	20	13;	29	5
δ Cephei		25.5	+57	54	3.7− 4.6	5	08.8	5	13;	16	7;	21	15;	27	0
Z Lacertae		36.9	+56	18	8.2− 9.0	10	21.1	5	16;	16	13;	27	11		
RR Lacertae		37.5	+55	55	8.5− 9.2	6	10.1	6	19;	13	5;	19	15;	26	1
V Lacertae	22	44.5	+55	48	8.5— 9.5	4	23.6	3	3;	13	2;	23	1;	28	1
SW Cassiop.	23	03.7	+58	11	9.2— 9.7	5	10.6	3	3;	14	0;	24	1;	30	8
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	5	15;	11	22;	24	13;	30	20
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4			11	14;	23	18		
V Cephei	23	51.7	+82	38	6.0—7.0	0	23.6	3	0;	12	23;	22	23;	27	22



LIGHT CURVE OF 023133 R TRIANGULI
Max. Feb. 27, 1916 (J.D. 2420921); mag. 6.3. Min. Oct. 31, 1915 (10.9)

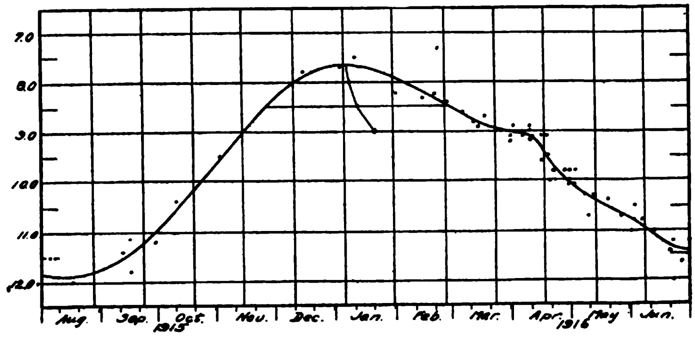
Observations by A.A. of V.S.O.

Chas B Lindsley
Cinti, O.



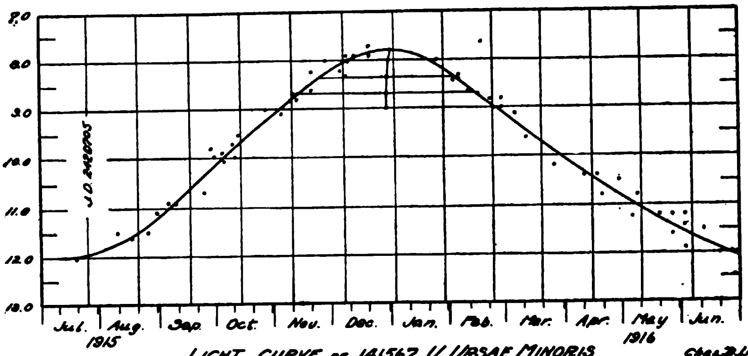
LIGHT CURVE OF 015254 U PERSEI
Maximum Feb. 4, 1916 (J.D. 2420898); mag. 8.0
Observations by Amer. Assn. of Variable Star Observers.

Chas. B. Lindsley
Cinti., O.



LIGHT CURVE OF 134440 R CANUM VENATICORUM
Max. Jan. 5, 1916 (J.D. 2420868); mag. 7.6
Observations by A. A. of V. S. O.

Chas. B. Lindsley
Cinti., O



LIGHT CURVE OF 141567 U URSAE MINORIS
Max. Dec. 1, 1915 (J.D. 2420863); Mag. 7.8
From observations by Amer. Assn. of Variable Star Observers.

Chas. B. Lindsley
Cinti., O.

COMET AND ASTEROID NOTES.

Comet 1916 *b* (Wolf).—On April 27 of the present year a faint object was discovered photographically by Dr. Max Wolf at Heidelberg. At first it was announced that a new asteroid had been discovered, but later the object proved to be a faint comet. Several parabolic orbits were calculated, but the following and latest one by Berberich seems to be the best.

$$
\begin{aligned}
T &= 1917 \text{ June } 16,1916 \text{ G. M. T.} \\
\omega &= 120^\circ\ 30' \\
\Omega &= 183\ \ 15 \\
i &= 25\ \ 35 \\
\log q &= 0.22786
\end{aligned}
$$

These elements show that at the time the comet was discovered it was nearly as far from the sun as Jupiter ($\log r = 0.69855$) and in fact was pretty near Jupiter's orbit. It was at the same time 4.09 units from the earth. It must be a very large comet to have been discovered at such a great distance from both the sun and earth, and it should become a naked eye object in a year from now, as it does not reach its perihelion until June 17, 1917. It will be an evening star until November 1 (1916) and a morning star during next spring and summer, coming into opposition September 16, 1917. From the above elements of Berberich I have computed the following ephemeris for the summer of 1917. From June 24 to September 28, 1917 the comet will be in the constellation Pegasus most of the time

EPHEMERIS BASED UPON BERBERICH'S ELEMENTS.

G.M.T.		α	δ	$\log r$	$\log \Delta$
1917		h m s	° ′ ″		
June	24	22 33 15	+24 1 51	0.22862	9.06986
July	2	22 47 40	+24 33 13	0.23106	0.05507
"	10	23 0 30	+24 37 30	0.23512	0.04084
"	18	23 11 33	+24 12 2	0.24070	0.02735
"	26	23 20 35	+23 14 41	0.24762	0.01501
Aug.	3	23 27 32	+21 43 24	0.25580	0.00473
"	11	23 32 26	+19 38 42	0.26502	9.99728
"	19	23 35 23	+17 2 32	0.27514	9.99387
"	27	23 36 44	+14 6 0	0.28596	9.99567
Sept.	4	23 36 53	+10 40 28	0.29736	0.00366
"	12	23 36 20	+ 7 14 47	0.30918	0.01826
"	20	23 35 38	+ 3 55 3	0.32132	0.03938
"	28	23 35 13	+ 0 52 8	0.33368	0.06623

F. E. SEAGRAVE.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, July, August, September, 1916.

The prosperity of the Association is well attested by the steady growth in its membership. Hardly a month passes without accessions to our ranks, and this awakening of observers to the practical nature of variable star observing is most encouraging and significant.

We welcome as new members this month the following observers:

Ed. de Perrot, Pasteur, L'Isle, Switzerland. "Pe"
Mr. William B. Newberry, Cleveland, O. "N"
Mr. Richard B. Waterhouse, Bourne, Mass. "Wa"

VARIABLE STAR OBSERVATIONS July, August, September, 1916.

001046
X Androm.

J.D. 242	Est.	Obs.
1052.8	<11.4	V
1078.7	12.7	Sp
1100.7	<13.0	Ba
07.6	13.5	B

001726
T Androm.

1049.8	8.9	M
51.9	9.2	E
52.8	9.0	V
65.7	8.3	Le
68.7	8.5	Ba
69.8	8.3	V
69.9	9.0	E
77.7	8.3	Sp
77.8	8.7	Le
78.7	8.7	Pi
81.8	8.6	V
89.7	8.6	Ba
97.7	9.2	Bl
97.8	9.2	V
99.7	8.9	M
1100.7	9.0	Ba
07.6	9.8	Nt
09.6	9.5	O

001755
T Cassiop.

1042.8	9.2	R
47.8	8.8	M
68.7	8.5	Ba
77.6	8.8	S
77.7	8.2	Sp
77.7	8.6	B
78.7	9.6	M
89.7	8.2	Ba
96.6	9.2	Bu
97.6	9.1	S
98.6	9.2	Wpi
98.6	8.8	Pi
1005.6	8.8	B
07.6	9.3	Nt
11.6	9.2	O

001838
R Androm.

1045.8	7.5	E
49.8	7.8	M
52.8	7.2	V
54.8	7.6	E
68.7	7.3	Ba
69.8	7.2	V
69.9	7.6	E
78.6	7.9	Wpi
78.6	7.9	Pi
81.8	7.7	V
89.7	7.9	Ba
97.8	8.2	V
99.8	8.1	M

R Androm.

J.D. 242	Est.	Obs.
1100.7	8.1	Ba
07.6	8.6	B
11.6	8.8	O

001909
S Ceti

1069.9	11.0	E
95.7	10.4	Ba
1104.7	10.3	M

002614
T Piscium

1105.7	10.0	M

003179
Y Cephei

1095.7	<13.0	Ba

004047
U Cassiop.

1045.6	11.1	L
50.8	11.0	M
51.6	10.8	Bu
54.8	10.9	E
68.7	10.0	Ba
69.8	9.8	E
70.8	10.0	M
78.6	9.2	B
89.7	10.0	Ba
92.6	9.9	B
94.7	9.5	M
98.6	9.9	Wpi
98.6	10.1	Pi
1100.7	9.8	Ba
05.7	10.0	M
07.6	10.3	Ba
07.6	10.0	Nt

004132
RW Androm.

1054.9	12.8	E
69.9	10.9	E
82.8	9.0	E
1100.8	7.9	E
01.6	7.9	Ba
04.7	8.1	M
06.7	7.9	O
07.6	8.0	B

004435
V Androm.

1054.9	11.2	E
68.7	10.4	Ba
69.9	10.2	E
70.9	10.0	M
78.7	9.9	Sp
82.9	9.8	E
89.7	9.2	Ba
95.7	9.0	Ba
1105.7	9.6	M
06.7	9.5	O
07.6	9.1	B
07.6	9.2	Ba

004533
RR Androm.

J.D. 242	Est.	Obs.
1050.8	11.8	E
51.6	11.3	Bu
68.7	11.8	Ba
69.8	11.6	E
70.8	11.5	M
82.8	10.8	E
89.7	9.8	Ba
95.7	9.1	Ba
1100.8	9.1	E
04.7	9.6	M
06.7	9.4	O
07.6	9.2	Ba

004746
RV Cassiop.

1045.6	<12.1	L
51.6	10.1	Bu
54.9	12.5	E
70.8	9.1	M
89.7	9.4	Ba
1100.7	9.3	Ba
05.7	9.9	M

004958
W Cassiop.

1008.4	9.2	L
1045.6	9.3	L
50.8	9.0	M
68.7	8.9	Ba
77.7	8.4	B
78.7	8.9	M
82.6	8.8	Ba
95.7	8.5	Ba
1105.6	8.6	B
07.6	9.0	Ba
07.7	9.5	Nt

010102
Z Ceti

1095.7	11.5	Ba

010940
U Androm.

1052.8	<11.8	E
70.8	<11.8	E
1100.7	<13.1	Ba

011272
S Cassiop.

1050.8	<11.1	M
68.7	<12.3	Ba
78.6	12.4	B
89.7	11.8	Ba
94.6	12.2	B
1106.6	11.7	Bu
07.6	12.0	Nt

011208
S Piscium

1052.9	<12.0	E
69.8	<11.6	V
81.8	<11.6	V
1106.6	<13.0	Ba

011712
U Piscium

J.D. 242	Est.	Obs.
1052.8	11.3	E
70.9	11.4	E
95.8	<12.3	Ba

012350
RZ Persei

1101.6	10.9	Ba

012502
R Piscium

1052.9	<11.8	E
70.9	11.2	E
73.8	<10.3	M
1105.7	10.7	M

013238
RU Androm.

1050.8	11.3	M
55.9	10.7	E
70.8	11.0	E
78.7	<11.5	Pi
95.7	12.5	Ba
1106.7	12.4	Ba

013338
Y Androm.

1050.8	10.8	M
52.8	11.1	E
55.9	11.2	E
70.8	11.2	E
78.6	<11.5	Pi
95.7	<13.0	Ba

014958
X Cassiop.

1051.6	11.5	Bu
57.9	11.6	M
70.9	11.4	M
77.7	10.2	B
84.8	11.6	M
94.6	10.5	B
1101.6	11.5	Ba

015354
U Persei

1057.9	10.4	M
69.8	9.8	V
81.8	9.3	V
84.8	9.2	M
97.8	9.0	V
1105.6	8.4	B
06.6	8.5	Ba

015912
S Arietis

1106.6	<12.9	Ba

021024
R Arietis

1048.9	<10.0	E
70.8	10.2	M
71.9	10.3	E

R Arietis

J.D. 242	Obs.	Est.
1084.8	9.4	M
97.7	9.0	Bl
98.6	8.8	Pi
1101.6	8.5	Ba
07.6	8.0	Ba

021143
W Androm.

1095.7	12.4	Ba

021403
o Ceti

1068.9	8.6	E
96.8	8.0	M
98.8	8.4	E
1107.7	8.2	M
07.7	8.3	Nt

021558
S Persei

1068.7	9.4	Ba
70.9	9.4	M
84.8	9.6	M
96.7	9.2	Ba
1105.6	9.3	B
07.6	9.0	Ba

022813
U Ceti

1107.7	10.2	M

023080
RR Cephei

1083.7	<10.9	M

023133
R Triang.

1059.9	10.4	M
70.9	11.4	E
79.7	12.0	Le
84.8	11.2	M
96.7	11.7	Ba
1107.6	11.8	Ba

024356
W Persei

1045.6	9.2	L
47.8	9.5	E
51.7	9.5	Pi
51.8	9.1	Le
57.9	8.9	M
65.7	8.9	Le
73.7	8.7	Ba
79.7	9.1	Le
84.8	9.4	M
96.7	8.9	Ba
98.6	9.4	Pi
1100.8	9.0	M
1106.7	9.0	Ba

025867
RX Cassiop.

1006.4	9.0	L

VARIABLE STAR OBSERVATIONS July, August, September, 1916—Continued.

030514
U Arietis

J.D.	Est.	Obs.
242		
1098.9	12.8	E
1196.7	<12.5	Ba

031401
X Ceti

J.D.	Est.	Obs.
1098.9	11.8	E

032043
Y Persei

J.D.	Est.	Obs.
1057.9	9.6	M
73.7	9.7	Ba
84.8	9.8	M
96.7	8.9	Ba
1100.8	10.2	E
00.8	10.1	M
07.6	9.6	B
07.6	9.9	Ba

032335
R Persei

J.D.	Est.	Obs.
1100.8	<10.4	E
06.7	<12.0	Ba

033362
U Camelop.

J.D.	Est.	Obs.
1079.7	7.2	Le
1096. 7	7.4	Ba

041619
T Tauri

J.D.	Est.	Obs.
1100.9	10.0	M

042215
W Tauri

J.D.	Est.	Obs.
1098.9	11.5	E
1100.8	<10.8	M
06.9	11.2	Nt

042209
R Tauri

J.D.	Est.	Obs.
1098.9	<10.6	E

042309
S Tauri

J.D.	Est.	Obs.
1098.9	<10.6	E

043065
T Camelop.

J.D.	Est.	Obs.
1096.7	10.8	Ba
1100.8	11.1	M
1107.6	11.3	Ba

043208
RX Tauri

J.D.	Est.	Obs.
1098.9	12.0	E

043274
X Camelop.

J.D.	Est.	Obs.
1008.4	11.9	L
39.4	11.6	L
49.9	10.8	E
51.7	10.6	Pi
242		
1081.6	8.0	Cr
96.7	8.0	Pi
1105.8	8.4	M
1106.7	8.2	O
06.7	8.2	Ba
09.7	8.2	O
10.6	8.4	O

045514
R Leporis

J.D.	Est.	Obs.
1096.9	8.0	M

050003
V Orionis

J.D.	Est.	Obs.
1098.9	11.0	E

050953
R Aurigae

J.D.	Est.	Obs.
1082.9	8.0	E
95.8	8.0	Ba
96.8	8.5	M

052034
S Aurigae

J.D.	Est.	Obs.
1095.8	7.9	Ba
96.8	9.0	M

052036
W Aurigae

J.D.	Est.	Obs.
1082.9	<11.5	E

053005
T Orionis

J.D.	Est.	Obs.
1098.9	9.7	E
06.8	10.1	Nt
1107.8	10.1	M

053531
U Aurigae

J.D.	Est.	Obs.
1096.8	10.0	M
1098.9	9.7	E

054319
SU Tauri

J.D.	Est.	Obs.
1098.9	9.4	E

054920
U Orionis

J.D.	Est.	Obs.
1100.9	8.4	M

054974
V Camelop.

J.D.	Est.	Obs.
1095.8	<12.6	Ba
1105.8	<10.9	M
06.7	<12.5	Ba

055353
Z Aurigae

J.D.	Est.	Obs.
1095.8	11.0	Ba
98.9	11.0	E
1100.9	11.0	M

060450
X Aurigae

J.D.	Est.	Obs.
1008.4	8.4	L
242		
82.9	<10.7	E
95.8	<12.0	Ba
1100.9	9.3	M

060547
SS Aurigae

J.D.	Est.	Obs.
1006.4	<11.2	L
18.4	<11.3	L
68.9	<10.8	E
69.9	<11.4	E
71.9	<10.8	E
82.8	<11.0	E
92.9	<10.8	E
95.8	<12.5	Ba
98.8	<12.6	E
1100.8	<12.6	E
00.9	<10.8	M

063558
S Lyncis

J.D.	Est.	Obs.
1082.9	<11.7	E

065355
R Lyncis

J.D.	Est.	Obs.
1071.9	< 9.7	E

070122
R Gemin.

J.D.	Est.	Obs.
1106.9	9.7	Nt

070122a
TW Gemin.

J.D.	Est.	Obs.
1106.9	8.5	Nt

070122b
Z Gemin.

J.D.	Est.	Obs.
1106.9	<10.2	Nt

073722
S Gemin.

J.D.	Est.	Obs.
1101.9	<10.1	M

074323
T Gemin.

J.D.	Est.	Obs.
1101.9	8.6	M

074922
U Gemin.

J.D.	Est.	Obs.
1006.3	<10.9	L
08.4	<11.7	L
18.4	<10.0	L

085120
T Cancri

J.D.	Est.	Obs.
1018.4	10.5	L

090151
V Urs. Maj.

J.D.	Est.	Obs.
1006.4	10.6	L
08.4	10.6	L
18.4	10.7	L
28.4	10.8	L
242		
1038.4	10.8	L
42.7	10.5	R
43.4	10.6	L
44.7	10.2	R
46.7	10.5	R
47.7	10.6	R
47.7	10.6	Mu

094211
R Leonis

J.D.	Est.	Obs.
1016.3	9.0	Pe
1028.4	9.0	L
44.7	8.7	R

095421
V Leonis

J.D.	Est.	Obs.
1045.6	12.6	B

103212
U Hydrae

J.D.	Est.	Obs.
1008.4	5.1	L
1019.7	5.2	G
36.7	5.2	G
38.7	5.2	G

103769
R Urs. Maj.

J.D.	Est.	Obs.
1050.6	12.5	Sc
51.6	<10.5	Wpi
51.6	<10.5	Pi
63.6	12.4	Ba
77.6	12.4	B
77.6	12.4	Ba
89.6	12.2	Ba
93.6	11.8	B
94.6	12.0	Ba
96.6	<10.5	Pi
99.6	11.8	M
1100.6	11.4	Ba
01.7	11.0	Sc
04.5	11.0	Ba
09.6	10.0	M

104620
V Hydrae

J.D.	Est.	Obs.
1008.4	6.2	L

115919
R Comae

J.D.	Est.	Obs.
1044.7	8.9	L
45.6	8.7	B

121418
R Corvi

J.D.	Est.	Obs.
1016.3	8.9	Pe
46.7	10.6	L

122532
T Can. Ven.

J.D.	Est.	Obs.
1063.6	10.0	Ba
67.7	10.2	M
73.6	10.3	Ba
80.6	10.6	Ba

123160
T Urs. Maj.

J. D.	Est.	Obs.
242		
1037.3	7.7	Pe
39.3	8.1	Pe
45.3	8.2	Pe
46.4	8.1	Pe
46.6	8.3	O
46.7	8.2	R
48.6	8.4	Ma
49.7	8.3	M
50	8.3	T
51	8.8	T
51.6	8.6	O
51.6	8.5	Wpi
51.6	8.5	Pi
51.6	8.1	Le
56.6	8.6	M
61. 6	9.0	O
82	8.7	T
63.6	8.8	Ba
63.7	9.0	Sc
64.6	9.0	O
66.6	9.0	E
67.7	8.9	M
68.7	8.6	R
73.6	9.2	Ba
73.7	9.3	Wh
77.6	9.6	S
1078.6	9.6	WPi
78.6	9.4	Ba
78.6	9.5	Pi
78.7	9.6	Bl
79.7	9.8	Le
82.6	9.6	Ba
89.6	10.1	Ba
93.6	10.8	Bu
93.6	10.0	Sc
93.6	10.2	B
94.6	10.4	Pi
94.6	10.3	Ba
98.6	10.4	Wh
99.6	11.4	M
1100.6	10.7	Ba
07.6	11.1	Ba

123307
R Virginis

J.D.	Est.	Obs.
1008.4	7.4	L
16.4	7.4	Pe
31.4	7.8	Pe
36.4	7.5	Pe
37.4	6.9	L
37.4	7.5	Pe
39.3	7.3	Pe
42.3	7.3	Pe
45.3	7.7	Pe
46.3	7.6	Pe
46.4	7.6	L
46.7	8.5	R
48.6	7.6	Ma
63.6	9.1	Ba

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123459
RS Urs. Maj.

J.D.	Est.	Obs.
242		
1063.6	11.7	Ba
73.6	10.7	Ba
73.7	10.8	Wh
78.6	10.1	Wpi
78.6	10.3	Pi
78.6	10.3	Ba
78.7	8.2	Bl
82.6	10.0	Ba
89.6	9.1	Ba
94.6	8.7	Pi
94.6	8.7	Ba
98.6	8.5	Wh
99.6	8.5	M
1100.6	8.7	Ba
01.7	8.0	Bl
07.6	8.6	Ba
09.6	8.6	M

123668
R Muscae

J.D.	Est.	Obs.
1036.7	6.6	G
38.7	6.8	G
46.7	7.1	G
47.7	7.3	G

123961
S Urs. Maj.

J.D.	Est.	Obs.
1018.5	11.3	L
43.4	9.2	L
46.6	9.2	O
48.6	9.4	Ma
51.6	9.0	O
51.6	8.8	Wpi
51.6	8.6	Pi
51.6	8.9	Ma
51.6	9.0	Le
56.6	8.5	M
61.6	8.7	O
62.7	8.2	B
63.6	8.5	Ba
63.7	8.9	Sc
64.6	8.5	O
66.6	8.6	Ma
67.7	8.3	M
68.7	9.1	R
72.6	8.5	Ma
73.6	8.3	Ba
73.7	8.5	Wh
77.6	8.5	S
78.6	8.4	Ma
78.6	8.5	Wpi
78.6	8.3	Pi
78.6	8.0	Ba
79.7	8.3	Le
82.6	7.9	Ba
89.6	8.3	Ba
92.6	8.1	Ma
93.6	8.5	Sc
92.6	8.3	Bu
94.6	8.5	Pi

S Urs. Maj.

J.D.	Est.	Obs.
242		
1094.6	7.9	Ba
96.6	8.1	Ma
98.6	8.3	Wh
99.6	8.1	Ma
1100.6	7.9	Ba
07.6	7.8	Ba
10.5	8.0	O

124606
U Virginis

J.D.	Est.	Obs.
1016.3	9.3	Pe
36.4	10.6	Pe
39.3	10.7	Pe
42.3	10.7	Pe
45.3	10.9	Pe
46.3	11.0	Pe

132422
R Hydrae

J.D.	Est.	Obs.
1008.4	5.5	L
16.3	5.9	Pe
19.7	5.2	G
28.4	5.3	L
35	6.2	Lu
36	6.2	Lu
36.7	5.3	G
37	6.2	Lu
38.7	5.3	G
40	6.1	Lu
41	6.2	Lu
42.4	5.2	L
43.4	5.3	L
46.4	5.6	L
46.7	6.0	R
47.7	5.4	G
66.7	5.4	G

132706
S Virginis

J.D.	Est.	Obs.
1008.4	11.9	L
43.4	<12.0	L

133273
T Urs. Min.

J.D.	Est.	Obs.
1048.6	9.8	V
62.6	9.3	M
63.6	9.0	Ba
66.6	8.7	V
72.6	9.1	M
73.6	9.0	Ba
80.6	9.0	Ba
83.6	9.3	M
88.6	9.3	Ba
93.6	9.8	V
1100.6	10.0	Ba
07.6	10.5	Ba

133633
T Centauri

J.D.	Est.	Obs.
1036.7	6.5	G
38.7	6.0	G

133674
V Urs. Min.

J.D.	Est.	Obs.
224		
1050	9.0	Υ

134440
R Can. Ven.

J.D.	Est.	Obs.
1018.5	10.6	L
45.5	10.6	L
63.6	11.4	Ba
73.6	11.3	Ba
78.6	11.0	B
80.6	11.0	Ba
83.6	10.4	M
88.6	10.4	Ba
94.6	10.2	Ba
1101.6	10.3	B
04.6	9.9	Ba

141567
U Urs. Min.

J.D.	Est.	Obs.
1051.6	11.0	Wpi
51.6	11.3	Pi
62.6	10.9	M
63.6	12.0	Ba
72.6	10.8	M
73.6	11.2	Ba
78.7	10.5	Sp
78.7	10.4	B
80.6	10.9	Ba
83.6	10.5	M
88.6	10.5	Ba
92.6	9.9	B
93.6	10.8	Bu
94.6	10.5	Pi
94.6	10.3	Ba
1100.6	9.7	Ba
07.6	9.3	Ba

141954
S Bootis

J.D.	Est.	Obs.
1046.7	8.6	Wh
46.7	8.6	R
51.7	8.1	Pi
63.6	8.3	Ba
68.6	8.5	M
73.6	8.6	Ba
77.6	8.8	S
77.6	8.8	B
78.6	<9.7	Sc
80.6	8.5	Ba
88.6	9.0	Ba
89.6	9.2	M
93.6	8.9	Bu
94.6	9.5	Pi
94.6	9.4	Ba

142205
RS Virginis

J.D.	Est.	Obs.
1068.6	9.3	Ba
77.6	9.8	Ba
89.6	9.9	Ba

142539
V Bootis

J.D.	Est.	Obs.
242		
1012.6	8.5	L
42.8	8.2	R
45.6	7.5	L
47.8	7.7	Wh
48.7	7.6	Ma
51.7	7.9	Wpi
51.7	7.6	Pi
51.8	7.4	Le
62.7	7.3	B
63.6	7.2	Ba
66.7	7.0	Ma
68.7	6.9	R
72.7	8.0	Mu
73.6	7.1	Ba
73.7	7.3	Pi
74.7	7.0	Ma
77.6	7.7	S
78.6	7.2	Hu
78.6	7.2	Ma
78.6	7.6	Sc
78.7	7.5	Mu
78.7	7.5	Bl
79.7	6.9	Le
80.6	7.3	Ba
83.6	7.2	Ma
88.6	7.2	Ba
89.6	7.6	M
92.6	7.4	Ma
93.6	7.8	Bu
94.6	7.6	Pi
94.6	7.1	Ba
95.7	7.8	Mu
98.6	7.6	Wh
1101.7	7.5	Bl
02.6	7.6	Ma
04.6	7.8	B
04.6	8.0	S
04.6	7.5	Ba
1110.5	8.0	O

142584
R Camelop.

J.D.	Est.	Obs.
1005.4	8.2	L
39.4	8.4	L
57.4	7.3	L
64.6	9.5	O
65.6	9.7	Le
71.7	9.5	R
72.6	10.0	M
73.6	9.7	Ba
77.7	10.3	Wh
77.6	10.0	B
79.7	10.1	Le
80.6	10.4	Ba
83.7	10.8	M
89.6	10.6	Ba
93.6	10.6	B
93.6	11.4	Bu
95.7	10.8	Wh

R Camelop.

J.D.	Est.	Obs.
242		
1100.6	11.1	Ba
04.6	11.5	Ba

143227
R Bootis

J.D.	Est.	Obs.
1012.6	8.3	L
45.6	6.9	L
46.7	7.0	Wh
46.7	7.2	R
46.7	7.3	M
48.6	7.2	Ma
51.7	8.0	Wpi
51.7	7.3	Pi
57.4	7.3	L
61.6	7.7	O
62.7	7.5	B
63.6	7.8	Ba
66.6	7.9	Ma
68.7	7.8	R
73.6	8.0	Ba
77.6	8.6	S
78.7	8.4	Bl
80.6	8.5	Ba
88.6	8.9	Ba
89.6	9.0	M
92.6	10.2	Sc
93.6	9.0	Bu
94.6	9.4	Pi
94.6	9.5	Wh
94.6	9.1	Ba
1101.7	9.2	Bl
04.6	10.0	Ba
05.6	9.8	B

144918
U Bootis

J.D.	Est.	Obs.
1064.7	10.4	B
66.6	10.4	V
68.6	10.8	Ba
77.6	10.9	Ba
81.6	10.8	V
89.6	10.5	Ba
91.6	10.4	B
93.6	<12.2	Bu
1107.6	<10.7	Ba

150605
Y Librae

J.D.	Est.	Obs.
1008.4	12.0	L
37.4	12.4	L
46.4	<12.0	L
63.6	<13.0	Ba

151520
S Librae

J.D.	Est.	Obs.
1008.4	11.2	L
37.4	9.9	L
46.4	9.6	L
47.4	10.1	R
71.7	9.7	R

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151614
S Serpentis

J.D. 242	Est.	Obs.
1048.6	10.3	V
66.6	9.1	V
68.6	8.7	Ba
77.6	8.7	Ba
81.6	9.1	V
88.6	8.6	Ba
94.6	8.6	Ba
95.6	9.1	V
1101.7	8.6	Bl
04.6	8.5	Ba

151731
S Cor. Bor.

1068.6	12.5	Ba
72.7	<11.1	Mu
77.6	12.6	B
77.6	12.6	Ba
89.6	<10.3	M
95.6	12.8	B
1107.6	12.8	Ba

151822
RS Librae

1008.4	8.2	L
37.4	9.7	L
46.4	10.0	L
69.6	11.1	B
1107.6	<11.5	B

152714
RU Librae

10064	8.4	L
18.4	8.3	L
37.4	9.0	L
46.4	9.2	L
47.4	10.1	R
63.6	10.7	B
1107.6	12.5	B

153378
S Urs. Min.

1039.4	9.1	L
47.7	9.4	R
47.7	8.8	Mu
50	9.7	T
51.6	9.8	Wpi
51.6	9.2	Pi
62.7	9.2	Mu
68.6	9.5	Ba
71.7	10.4	R
72.6	9.3	M
72.8	9.9	Mu
77.6	9.7	Ba
78.7	10.4	Mu
78.7	10.4	Bl
83.7	9.5	M
88.6	9.5	Ba
92.6	10.0	B
94.6	10.4	Pi
94.6	9.9	Ba
1101.7	10.5	Bl
04.6	10.0	Ba

. 154428
R Cor. Bor.

J.D. 242	Est.	Obs.
1006.4	6.0	L
08.4	6.0	L
1012.6	6.0	L
1015	6.0	Lu
16	6.1	Lu
17	6.2	Lu
1018.4	6.0	L
18	6.0	Lu
18.7	5.9	G
19	6.1	Lu
19.7	6.1	G
20	6.2	Lu
20.7	6.1	G
29	6.2	Lu
35	<6.2	Lu
35.7	6.1	G
36	<6.2	Lu
36.7	6.0	G
37	6.2	Lu
38.4	6.0	L
38.7	6.0	G
38	6.1	Lu
39.5	6.0	L
39	6.1	Lu
40	6.2	Lu
41	6.1	Lu
41.7	6.2	Mu
42.4	6.0	L
42.7	5.7	R
42.8	6.2	Mu
43.4	5.9	L
43.8	6.2	Mu
44.7	5.7	R
45.5	6.0	L
45.8	6.2	Lu
46.4	6.0	L
46.6	6.0	G
46.6	6.0	O
46.7	5.7	R
46.8	6.2	Mu
47.1	5.9	Lu
47.7	6.0	G
47.7	6.1	Mu
47.7	5.7	R
47.8	6.0	E
48.4	6.0	L
48.6	6.1	V
48.6	6.0	Ma
48.7	6.1	Lu
48.8	5.9	E
48.9	6.2	Mu
49.7	5.6	R
49.7	6.0	Mu
49.8	6.1	Lu
50.6	6.0	Ma
50.6	6.0	G
50.9	6.1	Mu
51.4	6.0	L
51.6	6.0	O
1051.6	6.0	Wh
51.6	6.0	Pi
51.8	5.9	E
52.6	6.0	Cr
54.8	5.8	E
54.8	6.0	Lu
54.8	6.1	Mu
55.6	5.8	Le
56.8	6.3	Lu
57.4	6.0	L
57.8	6.3	Lu
59.8	6.1	Lu
60.8	6.1	Lu
61.6	6.0	O
61.7	6.1	Mu
61.7	6.1	G
62.1	6.0	Lu
62.6	6.0	M
62.7	6.1	Mu
63.6	6.0	Ba
63.6	6.0	Sc
63.6	6.0	O
64.6	6.0	Gr
64.6	6.0	O
64.6	6.0	Cr
64.8	6.1	Lu
65.6	6.0	M
65.7	6.2	Mu
65.8	6.0	Lu
66.6	6.1	V
66.6	6.0	Ma
66.8	6.0	Mu
66.8	5.9	Lu
67.3	6.3	Gr
67.8	6.1	Mu
68.6	6.0	Ba
68.7	5.8	R
68.7	6.1	Mu
69.7	6.2	Mu
70.8	6.2	Mu
71.6	6.0	M
71.6	6.0	Ma
71.7	6.1	R
71.7	6.1	Mu
72.7	6.0	R
72.7	6.2	Mu
73.6	6.0	Ba
73.7	6.0	Pi
73.7	6.0	G
73.7	6.1	Mu
74.7	5.9	R
75.7	6.0	G
75.7	6.1	Mu
75.7	6.2	R
76.7	6.1	Mu
76.7	6.5	Sc
77.6	6.0	Ba
77.6	6.0	L
77.8	6.1	Mu
1078.6	5.9	Hu
78.6	6.0	Ba
78.6	6.0	Ma
78.6	6.0	Pi
78.6	6.0	Cr
78.7	6.1	Mu
78.7	6.0	Bl
78.7	6.1	R
79.7	6.1	Mu
79.7	5.7	Le
79.7	6.0	R
80.6	6.0	Ba
80.8	6.2	Mu
81.7	6.1	Mu
81.7	6.1	V
82.5	6.0	Ba
83.6	6.1	Ma
88.5	6.0	Ba
89.6	6.0	Ba
89.6	6.0	M
91.6	6.1	Ma
92.6	6.0	Ba
92.6	6.1	Ma
92.6	6.4	Sc
92.7	5.5	R
93.6	6.0	Ba
93.6	6.1	V
93.6	6.0	Sc
93.8	6.1	Mu
94.6	6.0	Ba
94.6	6.4	Gr
94.7	5.7	R
95.6	6.0	Ba
95.6	6.4	Gr
95.7	6.0	Bl
95.7	6.0	Wh
95.7	6.1	Mu
96.6	6.0	Ma
96.6	6.0	Pi
96.6	6.2	Bu
96.6	6.0	Ba
96.7	6.0	Mu
97.7	6.0	Bl
99.6	6.0	Ma
99.7	6.0	Bl
1100.7	6.0	Bl
00.6	6.1	Ba
01.5	6.0	Ba
01.6	6.4	Gr
01.7	6.0	Bl
03.7	6.0	Bl
04.5	6.0	Ba
04.6	6.5	Sc
04.6	6.0	S
04.6	6.0	M
06.6	6.0	Cr
06.6	6.0	Ba
07.6	6.0	Ba
09.6	6.0	O

R Cor. Cor.

J.D. 242	Est.	Obs.
1109.6	6.0	M
10.5	6.0	O
11.5	6.0	O

154536
X Cor. Bor.

1036.6	9.6	Ba
73.6	9.7	Ba
77.6	10.3	Ba
88.6	10.9	Ba
94.6	11.4	Ba
1104.6	12.0	Ba

154539
V Cor. Bor.

1052.7	10.3	Pi
65.6	11.0	M
68.6	10.0	Ba
77.6	9.3	Ba
88.6	9.4	Ba
89.6	10.5	M
94.6	8.7	Ba
1104.6	8.8	Ba

154615
R Serpentis

1016.4	8.2	Pe
37.3	8.1	Pe
46.6	9.0	O
47.7	9.5	R
47.7	9.0	Mu
48.6	8.8	Ma
49.7	9.3	Mu
51.6	9.3	O
52.6	9.3	Cr
61.6	9.6	O
62.6	9.8	M
62.7	10.1	Mu
64.6	9.7	O
68.6	10.5	Ba
71.7	10.1	R
72.7	10.4	Mu
77.6	10.3	Ba
78.7	10.5	Mu
78.7	10.9	B
88.6	10.8	Ba
92.6	11.0	B
94.6	11.1	Ba
99.6	11.2	M
1104.6	11.7	Ba

155229
Z Cor. Bor.

1077.6	<12.8	Ba
1100.6	<13.0	Ba

Variable Star Observations July, August, September, 1916—Continued.

155378

S Urs. Min.

J.D. 242	Est.	Obs.
1093.6	10.2	Bu

155847

X Herculis

J.D. 242	Est.	Obs.
1020.7	6.6	G
36.7	6.5	G
41.7	6.3	Mu
42.8	6.4	Mu
43.8	6.4	Mu
45.8	6.3	Lu
46.8	6.2	Mu
47.7	6.2	Mu
48.9	6.3	Mu
49.7	6.2	Mu
50.9	6.1	Mu
54.8	6.5	Lu
56.8	6.3	Lu
57.8	6.3	Lu
60.8	6.2	Lu
61.7	6.4	G
61.8	6.1	Lu
64.6	5.9	Nt
64.8	6.0	Lu
65.8	6.0	Lu
66.8	5.9	Lu
69.7	6.2	Mu
70.8	6.2	Mu
71.7	6.2	Mu
72.7	6.3	Mu
73.7	6.0	Mu
74.6	6.7	Nt
74.7	5.6	Ma
75.7	6.0	Mu
76.7	6.0	Mu
77.8	6.0	Mu
78.7	6.0	Mu
79.7	6.0	Mu
80.6	6.5	Nt
80.8	6.0	Mu
81.7	6.0	Mu
88.6	6.0	Nt
93.8	6.0	Mu
94.6	6.1	Nt
95.7	5.9	Mu
96.7	5.9	Mu
1101.5	6.4	Nt
06.6	6.6	Nt
1110.5	6.5	O
11.5	6.4	O

160118

R Herculis

J.D. 242	Est.	Obs.
1088.6	<13.0	Ba
95.6	<10.7	V
1101.6	<13.5	B

160210

U Serpentis

J.D. 242	Est.	Obs.
1077.6	12.8	B
80.6	12.5	Ba
89.6	11.9	Ba

U Serpentis

J.D. 242	Est.	Obs.
1094.6	11.2	B
94.6	11.4	Ba
96.6	11.6	Bu
1104.6	10.5	Ba
07.6	10.4	Ba

160625

RU Herculis

J.D. 242	Est.	Obs.
1048.7	7.9	V
66.7	7.9	V
68.6	7.0	Ba
71.6	8.0	M
77.6	7.1	Ba
81.7	7.9	V
83.7	8.0	M
88.6	7.4	Ba
94.6	7.4	Ba
95.6	8.0	V
96.6	8.2	Pi
96.6	8.0	Bu
1104.6	7.9	B
04.6	7.9	Ba
1110.6	8.1	O

161138

W Cor. Bor.

J.D. 242	Est.	Obs.
1068.6	9.0	Ba
73.6	8.8	Ba
80.6	8.4	Ba
88.6	8.5	Ba
91.6	8.8	B
94.6	8.4	Ba
1004.6	9.0	Ba
10.6	9.5	O

162112

V Ophiuchi

J.D. 242	Est.	Obs.
1006.4	8.8	L
39.5	9.2	L
47.7	9.6	R
48.4	9.6	L
52.6	9.6	Wpi
52.6	9.4	Pi
68.6	9.3	Ba
71.7	9.3	R

162119

U Herculis

J.D. 242	Est.	Obs.
1046.6	7.6	O
47.7	7.1	Mu
47.7	8.2	R
48.6	7.8	Ma
51.6	7.8	O
61.6	7.9	O
62.7	7.4	Mu
64.6	8.0	O
64.6	8.2	Gr
65.6	8.3	M
66.6	8.2	Ma
67.6	8.0	Gr

U Herculis

J.D. 242	Est.	Obs.
1068.6	7.7	Ba
72.7	8.2	R
72.8	8.0	Mu
73.7	8.3	Pi
77.6	7.4	Ba
78.6	8.5	Ma
78.6	8.5	Sc
78.7	8.5	Bl
78.8	8.3	Mu
83.7	8.3	M
88.6	7.9	Ba
93.6	8.7	Ma
94.6	8.1	Ba
94.6	8.5	Gr
95.6	8.0	Gr
95.7	8.4	Mu
96.6	8.8	Ma
96.6	8.8	Pi
98.6	8.7	Wh
1101.6	8.3	Gr
01.7	9.0	Bl
02.6	8.9	Ma
04.6	8.5	B
04.6	8.9	S
04.6	8.4	Ba
07.6	9.2	Nt
10.6	9.2	O

162807

SS Herculis

J.D. 242	Est.	Obs.
1006.4	11.5	L
39.4	9.7	L
43.4	9.2	L
48.4	9.3	L
66.7	10.1	V
51.4	9.0	L
66.7	10.1	V
68.6	9.9	Ba
78.6	10.8	Ba
81.7	<11.4	V
88,6	12.0	Ba
94.6	12.3	Ba
95.6	<11.4	V
1004.6	12.8	Ba
06.6	12.6	Ba

162816

S Ophiuchi

J.D. 242	Est.	Obs.
1078.6	13.2	Ba

163137

W Herculis

J.D. 242	Est.	Obs.
1062.7	12.2	Le
68.6	<12.3	Ba
78.6	9.0	Hu
78.7	12.8	Sp
78.6	13.0	Ba
79.7	<12.2	Le
99.6	11.3	M

W Herculis

J.D. 242	Est.	Obs.
1101.6	13.4	B
07.6	13.4	Ba

163172

R Urs. Min.

J.D. 242	Est.	Obs.
1047.7	9.5	R
51.6	9.4	Wpi
51.6	9.4	Pi
65.6	9.6	M
68.6	9.4	Ba
72.6	9.7	M
72.7	9.5	R
78.6	9.1	Ba
83.7	9.5	M
88.6	9.0	Ba
92.6	9.0	B
94.6	9.4	Pi
94.6	9.1	Ba
1102.6	9.4	Ma
04.6	9.1	Ba
05.6	9.4	Wh

163266

R Draconis

J.D. 242	Est.	Obs.
1047.7	<11.0	R
65.6	<11.7	M
65.6	12.0	Le
68.6	11.8	Ba
77.6	<11.0	Wh
78.6	<11.8	Cr
78.6	11.9	Ba
79.7	<11.2	Le
89.6	12.1	Ba
95.7	<11.0	Wh
1104.6	12.2	Ba
05.7	<11.0	Wh
06.6	12.7	B

164055

S Draconis

J.D. 242	Est.	Obs.
1047.7	8.4	R
68.6	8.5	Ba
70.8	8.4	M
72.8	8.4	R
78.6	8.4	Ba
83.7	9.1	M
89.6	8.7	Ba
1100.6	8.7	Ba
1107.6	9.1	M
07.6	9.1	Ba

164319

RR Ophiuchi

J.D. 242	Est.	Obs.
1078.6	<12.5	Ba
1094.6	<12.4	B

164715

S Herculis

J.D. 242	Est.	Obs.
1047.7	11.1	R
65.7	11.1	M

S Herculis

J.D. 242	Est.	Obs.
1068.6	11.5	Ba
72.7	<11.0	R
78.6	11.9	Ba
98.6	<11.5	Wh
99.6	11.7	M
1100.6	12.1	Ba
01.6	11.2	B

165030

RR Scorpii

J.D. 242	Est.	Obs.
1047.7	9.0	R
72.7	9.5	R

165631

RV Herculis

J.D. 242	Est.	Obs.
1068.6	<13.4	Ba
78.6	<13.7	Ba
78.7	<14.0	Sp
94.6	12.8	Ba
1101.6	11.0	B
06.6	10.6	Ba

170215

R Ophiuchi

J.D. 242	Est.	Obs.
1006.4	7.8	L
39.5	10.0	L
51.8	<10.2	E
52.6	<10.0	Wpi
52.6	<10.0	Pi
68.6	11.9	Ba
78.6	11.9	Ba

170627

RT Herculis

J.D. 242	Est.	Obs.
1065.7	11.5	M
68.6	12.6	Ba
78.6	12.7	Ba
1104.6	13.0	B

171333

68 *u* Herculis

J.D. 242	Est.	Obs.
1042.3	4.9	Pe

171401

Z Ophiuchi

J.D. 242	Est.	Obs.
1046.6	8.9	O
48.7	9.0	V
49.8	9.5	E
66.7	9.1	V
68.6	9.3	Ba
78.6	9.3	Ba
81.7	10.1	V
89.6	9.6	Ba
95.6	10.4	V
96.6	9.7	Ba
1106.6	10.0	Ba

171723

RS Herculis

J.D. 242	Est.	Obs.
1047.7	9.0	Mu
48.7	8.5	V

VARIABLE STAR OBSERVATIONS July, August, September, 1916—Continued

RS Herculis

J.D. 242	Est.	Obs.
1049.7	9.0	Mu
62.7	9.3	Mu
65.7	9.3	M
66.7	9.4	V
68.6	9.5	Ba
72.8	9.5	Mu
78.6	9.8	Ba
78.7	9.8	Sp
78.8	10.0	Mu
81.7	9.8	V
88.6	10.5	Ba
91.6	10.5	B
94.6	11.4	Ba
95.6	10.4	V
95.7	10.9	Mu
96.7	11.0	Pi
97.7	11.0	Wh
99.6	11.4	M
1106.6	11.8	Ba
07.6	12.0	Nt

172808
RU Ophiuchi

1048.7	<11.2	V
64.7	12.8	B
66.7	<11.6	V
68.6	13.0	Ba
78.6	<13.5	Ba
81.7	<11.2	V
82.8	<11.8	E
98.6	<13.0	B

175111
RT Ophiuchi

1045.6	12.9	B
78.6	<13.0	Ba
98.6	<12.8	B

175458
T Draconis

1066.7	<11.4	V
78.6	11.0	Ba
81.7	<10.4	V
89.6	10.9	Ba
95.7	<10.4	V
96.6	11.2	Ba
1106.6	11.0	B
06.6	11.0	Ba
07.6	10.1	M

175519
RY Herculis

1048.8	9.9	E
54.8	9.0	E
68.6	8.7	Ba
78.6	8.5	Ba
82.8	8.8	E
88.6	8.4	Ba
91.6	8.5	B
96.6	8.6	Ba
1106.6	8.8	Ba
07.6	9.1	Nt

180531
T Herculis

J.D. 242	Est.	Obs.
1047.7	8.4	Mu
48.7	8.5	Ma
49.7	8.5	Mu
51.6	8.5	O
61.6	8.1	O
62.7	8.3	Mu
64.6	8.4	O
65.6	8.7	M
67.6	8.5	Gr
68.6	8.4	Ba
72.6	8.4	Ma
73.7	8.5	Pi
74.7	8.7	R
78.7	8.5	Bl
78.7	8.3	Sc
78.8	8.5	Mu
80.6	8.6	Ba
82.8	9.0	E
83.7	9.0	M
88.6	9.2	Ba
91.6	9.4	Bu
96.6	9.6	Pi
96.6	9.7	Ma
96.6	9.6	Ba
1101.7	10.0	Bl
05.7	9.6	Wh
06.6	10.5	B
06.6	11.0	Ba

180565
W Draconis

1068.6	10.8	Ba
73.6	10.2	Ba
78.6	10.2	Ba
88.6	9.5	Ba
96.6	9.3	Ba
96.6	9.7	M
1106.6	9.0	B
06.6	9.1	Ba

180666
X Draconis

1099.6	<11.5	M

181103
RY Ophiuchi

1048.7	<11.3	V
77.6	12.8	B
94.6	10.5	B
95.7	10.4	V
96.6	10.5	Ba
1106.6	9.1	Ba

181136
W Lyrae

1047.7	10.4	Mu
48.8	9.5	E
49.7	10.4	Mu
51.6	9.5	O
61.7	10.0	Mu

W Lyrae

J.D. 242	Est.	Obs.
1062.7	9.9	Mu
65.6	9.2	Le
67.6	8.9	M
72.7	9.1	Mu
73.6	8.4	Ba
74.7	8.8	R
76.6	8.4	Sc
78.7	8.5	Mu
78.7	8.1	Bl
79.7	8.3	Le
80.6	8.1	Ba
88.6	7.6	Ba
89.6	7.6	M
91.6	8.2	Bu
96.6	7.3	Ba
96.7	7.8	Pi
1106.6	7.6	B
06.6	7.4	Ba
06.7	7.8	O
09.6	7.4	M

182224
SV Herculis

1068.7	10.6	Ba
78.6	10.7	Ba
82.8	10.8	E
88.6	10.9	Ba
91.6	11.1	B
96.6	11.5	Ba
1106.6	12.2	Ba

182306
T Serpentis

1048.7	10.3	V
62.6	11.0	M
66.7	11.0	V
68.6	11.6	Ba
74.7	9.9	R
78.6	11.5	Ba
81.7	11.2	V
83.7	12.0	M
95.7	<11.2	V
96.6	12.4	Ba

183225
RZ Herculis

1080.6	10.0	Ba
88.6	9.5	Ba
96.6	9.2	Ba
1106.6	8.9	Ba

183308
X Ophiuchi

1008.4	8.4	L
39.5	7.9	L
48.7	8.4	Ma
48.7	8.4	V
48.8	8.5	E
51.4	8.4	L
52.6	8.5	Wpi

X Ophiuchi

J.D. 242	Est.	Obs.
1052.6	8.2	Pi
62.6	8.0	M
66.7	7.9	V
66.7	8.4	Ma
68.7	8.0	Ba
74.6	8.0	Ma
74.7	7.7	R
78.6	8.0	Ma
78.6	7.8	Ba
81.7	7.3	V
88.6	7.0	Ba
91.6	7.6	Bu
93.6	7.5	Ma
93.6	7.0	M
96.6	7.2	Ba
96.6	7.5	Ma
96.7	7.5	Pi
99.6	7.3	Ma
1107.6	6.8	Ba

184134
RY Lyrae

1080.6	<13.3	Ba

184243
RW Lyrae

1048.8	<12.8	E
80.6	<13.4	Ba
1105.7	<13.8	Sp
06.6	<13.6	B

184205
R Scuti

1006.4	5.3	L
18.4	5.3	L
28.4	5.4	L
30.4	5.6	Pe
37.4	5.7	Pe
39.4	5.5	Pe
41.7	5.9	Mu
42.7	5.1	R
42.8	6.0	Mu
43.4	5.4	L
43.8	5.9	Mu
44.7	5.1	R
45.4	5.8	Pe
46.3	5.9	Pe
46.6	6.0	O
46.7	6.1	R
46.8	5.9	Mu
47.7	6.1	R
47.7	6.0	Mu
47.7	5.8	G
47.8	5.9	E
48.6	5.6	Ma
48.8	6.0	E
48.9	5.9	Mu
49.7	6.0	Mu
50.6	5.7	Ma
50.9	6.0	Mu

R Scuti

J.D. 242	Est.	Obs.
1051.4	5.8	L
51.6	6.4	O
51.6	6.2	Wh
51.7	5.5	Le
52.6	5.6	Wpi
52.6	6.0	Pi
54.8	6.1	Mu
57.4	6.2	L
60.8	6.1	Lu
61.6	6.9	Bu
61.8	6.0	Lu
62.7	7.0	Mu
63.6	6.4	Ba
64.6	7.0	O
64.6	7.0	Nt
64.6	7.4	Bu
64.8	5.9	Lu
65.7	7.2	Mu
65.8	6.0	Lu
66.6	6.9	Ma
66.7	6.4	G
66.8	6.0	Lu
67.7	7.1	M
68.6	6.9	Ba
68.8	7.2	M
68.7	7.1	R
68.7	7.2	Mu
69.7	7.4	Mu
70.8	7.6	Mu
71.6	7.0	Ma
71.6	7.2	M
71.7	6.8	R
71.7	7.5	Mu
72.7	7.4	R
72.7	7.2	Mu
73.6	7.1	Ba
73.7	7.3	Pi
73.7	7.2	Mu
73.7	7.1	G
74.7	7.2	Ma
74.7	7.4	R
75.7	7.1	Mu
75.7	7.5	R
75.7	7.3	G
76.6	7.4	Bu
77.6	7.5	Nt
77.6	7.3	Ba
77.6	7.6	Wh
77.8	7.2	Mu
78.6	7.3	Ba
78.6	7.4	Wpi
78.6	7.6	Pi
78.6	7.4	Bu
78.7	7.2	M
76.7	7.1	Mu
78.7	7.3	R
79.7	7.2	Mu
79.7	7.3	R
79.7	7.2	Le

Variable Star Observations July, August, September, 1916—Continued.

R Scuti

J.D.	Est.	Obs.
242		
1080.6	7.2	Ba
81.7	7.2	Mu
82.5	7.3	Ba
83.6	7.2	Ma
83.7	7.3	M
85.6	7.0	Ma
88.5	6.9	Ba
89.6	7.0	M
89.6	6.6	Ba
90.6	6.9	Bu
91.6	6.5	Bu
91.6	6.2	Wh
91.6	6.3	Ma
91.6	6.0	Cr
92.6	6.2	Ma
92.7	6.3	R
93.7	6.3	Ba
93.6	5.9	Cr
93.6	6.0	Ma
93.7	6.1	Ba
93.8	6.5	Mu
94.5	5.5	Pi
94.6	6.0	Ma
94.7	5.9	R
94.8	5.9	Mu
95.6	6.0	Ba
95.7	6.0	Mu
95.6	5.9	Bu
96.6	5.5	Pi
96.6	5.9	Ba
96.6	5.8	Ma
96.6	5.5	Le
96.7	6.0	Mu
97.6	5.7	Bu
97.7	5.8	Bl
98.6	5.0	M
99.6	5.7	Ma
1100.6	5.9	Ba
01.5	5.7	Ba
01.5	5.2	Pi
01.7	5.8	Bl
02.6	5.6	Ma
02.6	5.5	Bu
04.5	5.6	Ba
05.6	5.2	Bu
06.6	5.0	Bu
06.6	5.6	Ba
06.7	5.3	O
07.6	5.6	Ba
09.6	5.3	O
09.6	5.0	M
10.6	5.3	O
11.6	5.3	O

185032
RX Lyrae

J.D.	Est.	Obs.
1080.6	<13.5	Ba

185634
Z Lyrae

J.D.	Est.	Obs.
242		
1082.6	<13.0	Ba
96.6	<13.3	Ba

190108
R Aquilae

J.D.	Est.	Obs.
1008.4	9.9	L
39.5	7.2	L
48.7	5.9±	V
51.4	6.7	L
51.7	6.3	Sc
62.6	6.2	M
62.7	6.2	B
66.7	6.1	V
68.7	6.0	Ba
73.6	6.1	Sc
78.6	5.9	Ba
78.7	6.5	Sc
81.7	6.1	V
88.6	6.0	Ba
94.6	5.8	M
95.6	7.6	Bu
95.6	6.0	Sc
95.7	6.0	Bl
96.6	6.1	Ba
97.7	6.5	V
1105.6	6.1	B
06.6	6.5	Ba

190529
V Lyrae

J.D.	Est.	Obs.
1065.6	<11.4	Nt
68.7	<12.4	Ba
78.6	13.0	Ba

190926
X Lyrae

J.D.	Est.	Obs.
1046.6	9.2	O
51.6	9.2	Ma
51.6	9.2	Sc
71.6	9.3	M
73.6	8.9	Ba
74.7	8.3	R
73.6	8.9	Ba
74.7	9.3	R
76.7	8.4	Sc
78.6	9.3	Ma
82.8	9.1	E
89.6	8.8	M
95.7	9.3	Bl
96.6	9.2	Ma
96.6	7.5	Ba
1106.6	9.3	Ba

191019
R Sagittarii

J.D.	Est.	Obs.
1045.5	8.7	L
48.9	<10.9	E
51.7	8.4	Wpi
51.7	8.5	Pi
68.7	8.1	Ba

R Sagittarii

J.D.	Est.	Obs.
242		
1075.7	7.9	R
78.6	8.1	Ba
89.6	8.0	Ba
95.6	8.2	Bu
96.6	8.2	Ba
97.7	8.0	Bl
1105.6	8.3	B
06.6	8.5	Ba

191033
RY Sagittarii

J.D.	Est.	Obs.
1039.5	< 9.7	L
45.5	< 9.6	L
75.7	<10.5	R
79.7	< 9.8	R
92.7	<10.0	R
94.7	<10.1	R
1104.6	<11.5	Ba

191350
TZ Cygni

J.D.	Est.	Obs.
1073.6	10.5	Ba
78.6	10.4	Ba
80.6	10.4	Ba
96.6	10.2	Ba
1106.6	10.3	Ba

191637
U Lyrae

J.D.	Est.	Obs.
1042.7	10.7	R
65.6	10.4	Nt
68.7	10.2	Ba
71.6	10.3	M
75.7	10.3	R
78.6	9.0	Ba
82.8	10.2	E
88.7	9.5	Ba
89.6	10.4	M
96.6	9.0	Ba
1106.6	9.3	Ba

192928
TY Cygni

J.D.	Est.	Obs.
1048.9	12.0	E
52.7	<11.2	V
64.6	<12.0	Nt
71.6	<11.2	M
78.6	13.1	Ba
82.8	<11.9	E

193311
RT Aquilae

J.D.	Est.	Obs.
1018.4	9.6	L
43.4	10.2	L
68.7	11.1	Ba
78.6	11.3	Ba
96.6	12.2	Ba
1106.6	12.8	Ba

193449
R Cygni

J.D.	Est.	Obs.
242		
1019.7	7.7	Le
37.3	8.1	Pe
39.3	8.1	Pe
42.3	7.9	Pe
46.4	6.9	Pe
47.7	7.2	Mu
48.7	7.1	Ma
48.9	7.2	E
51.6	6.9	O
51.7	7.1	Le
56.6	6.6	M
62	8.0	T
63.6	7.0	O
66.6	7.1	Ma
68.7	7.0	Ba
71.6	7.7	M
72.7	6.9	Mu
75.7	7.3	R
76.6	6.6	Sc
78.6	7.2	S
78.6	7.1	Hu
78.6	7.1	Ma
78.7	7.1	Mu
80.6	7.1	Ba
82.8	7.2	E
83.6	7.1	Ma
88.7	7.1	Ba
90.6	7.4	M
92.6	7.3	Ma
95.7	7.2	Mu
96.6	7.8	Pi
96.6	7.3	Le
96.6	7.5	Ma
96.6	7.2	Ba
97.7	8.0	Bl
1002.6	7.7	Ma
02.6	7.6	Bu
06.6	7.3	Ba

193509
RV Aquilae

J.D.	Est.	Obs.
1048.8	12.4	E
73.6	<13.0	Ba
80.6	<13.1	Ba
1100.6	<13.2	Ba

193732
TT Cygni

J.D.	Est.	Obs.
1018.4	7.4	L
42.7	7.9	R
43.4	7.3	L
48.6	8.3	Ma
66.7	8.2	Ma
71.6	8.2	M
73.6	7.3	Ba
74.6	8.0	Ma
78.6	8.1	Hu
78.6	8.4	Ma
78.7	8.0	R
80.6	7.4	Ba

TT Cygni

J.D.	Est.	Obs.
242		
1092.6	8.4	Ma
96.6	7.6	Ba
96.6	8.4	Ma
97.7	8.3	Bl
98.6	8.3	M
1006.6	7.4	Ba

194048
RT Cygni

J.D.	Est.	Obs.
1019.7	8.1	Le
47.7	9.4	Mu
48.9	9.6	E
51.6	9.7	O
51.7	9.9	Le
56.6	10.0	M
62	9.7	T
63.6	10.0	O
68.7	11.0	Ba
75.7	<11.0	R
76.7	10.8	Sc
78.6	11.3	Hu
78.6	11.5	Ba
82.8	11.5	E
88.7	11.9	Ba
96.6	11.0	Le
96.6	11.4	Ba
99.6	11.2	M
1106.6	11.0	Ba

194348
TU Cygni

J.D.	Est.	Obs.
1042.7	10.2	R
48.9	9.9	E
56.6	9.4	M
68.7	10.0	Ba
75.7	9.9	R
78.6	10.5	Hu
78.6	10.1	Ba
82.8	10.9	E
88.7	10.6	Ba
96.6	11.1	Ba
97.7	11.0	Bl
99.6	11.4	M
1106.6	12.0	Ba

194604
X Aquilae

J.D.	Est.	Obs.
1042.7	9.3	R
52.7	11.0	V
64.6	11.1	Nt
66.7	11.1	V
66.6	11.3	M
68.7	11.2	Ba
78.6	11.3	B
78.6	11.1	Ba
78.7	10.6	R
81.7	<11.3	V
95.6	12.2	B
1100.6	12.5	Ba

VARIABLE STAR OBSERVATIONS July, August, September, 1916—Continued.

194632
χ Cygni

J.D. 242	Obs.	Est.
1016.4	10.7	Pe
18.4	11.9	L
36.4	11.7	Pe
37.3	11.6	Pe
39.4	11.7	Pe
45.4	11.7	Pe
46.4	11.8	Pe
48.8	<12.2	E
64.6	12.9	B
78.6	<12.0	Hu
78.6	12.6	Ba
1106.6	<13.0	B

195116
S Sagittae

1041.7	5.8	Mu
42.7	6.1	R
42.8	5.8	Mu
43.8	5.8	Mu
46.6	5.9	O
46.8	6.0	Mu
47.8	8.0	Mu
48.9	6.0	Mu
49.7	6.1	Mu
50.9	6.1	Mu
51.6	5.9	O
54.8	5.7	Lu
54.8	5.8	Mu
57.8	5.6	Lu
60.8	5.9	Lu
61.6	5.7	O
61.8	5.9	Lu
62.7	5.4	Mu
63.6	5.7	O
64.6	5.8	O
64.8	5.7	Lu
65.7	5.7	Mu
65.8	5.8	Lu
66.8	5.7	Lu
68.7	6.0	Mu
69.7	5.9	Mu
70.8	5.7	Mu
71.7	5.6	Mu
72.7	5.6	Mu
73.7	5.7	Mu
75.7	6.0	Mu
76.7	5.9	Mu
77.8	5.4	Mu
78.7	5.4	Mu
78.7	6.2	R
79.7	5.6	Mu
79.7	5.8	R
81.7	5.8	Mu
92.7	6.2	R
94.7	6.0	O
94.8	5.4	Mu
95.6	5.8	Bu
95.7	5.5	Mu
96.7	5.4	Mu

S Sagittae

J.D. 242	Obs.	Est.
1106.7	5.7	O
09.6	5.8	O
10.5	5.7	O
11.5	5.4	O

195849
Z Cygni

1047.7	<11.0	Mu
62	<11.0	ϒ
64.7	12.5	B
66.7	<11.6	V
71.6	11.2	M
72.7	11.3	Mu
73.6	10.4	Ba
78.7	11.1	Mu
80.6	8.9	Ba
81.7	9.2	V
89.6	8.1	Ba
90.6	8.4	M
91.6	8.1	B
95.7	9.2	Mu
97.7	8.0	V
1101.5	8.2	Pi
01.6	7.8	Ba
02.6	8.5	Bu

200212
SY Aquilae

1046.6	<10.8	O
51.8	11.9	E
64.6	12.0	B
68.7	12.1	Ba
72,6	12.0	M
78.7	12.0	Ba
1101.6	12.5	B
01.6	12.2	Nt
05.6	12.2	M

200357
S Cygni

1045.6	<13.3	B
82.6	<13.0	Ba
89.6	<11.4	M

200525
W Vulpeculae

1033	9.1	ϒ
50	9.1	ϒ
51	9.3	ϒ
63	9.3	ϒ
64	8.9	ϒ

200647
SV Cygni

1047.8	8.8	Mu
48.7	9.1	Ma
49.7	9.0	Mu
51.7	8.3	Le
52.6	9.0	Wpi
52.6	9.3	Pi
61.7	9.2	Mu
62.7	9.3	Mu
66.7	9.2	Ma

SV Cygni

J.D. 242	Est.	Obs.
1067.6	9.1	M
71.6	9.3	Ma
72.6	9.2	Mu
73.6	8.2	Ba
78.6	9.2	Ma
78.7	9.2	Mu
78.7	9.3	R
80.6	8.2	Ba
83.6	9.0	Ma
89.6	9.0	M
92.6	9.1	Ma
95.7	9.0	Mu
96.6	9.5	Wpi
96.6	9.5	Pi
96.6	9.0	Ma
97.7	9.2	Bl
98.6	9.0	M
1100.6	8.5	Ba
07.6	8.4	Ba

200715a
S Aquilae

1039.5	10.5	L
42.8	10.3	R
43.4	10.5	L
51.4	11.2	L
65.6	11.3	B
65.7	11.4	M
73.6	10.5	Ba
79.7	10.3	R
80.6	10.5	Ba
89.6	10.3	Ba
90.6	11.0	Bu
91.6	10.1	B
92.7	10.3	Ba
93.6	10.4	M
94.6	9.7	Ba
96.6	9.8	Ba
1100.6	9.8	Ba
01.6	10.1	Pi
01.6	9.8	Ba
04.6	9.6	Ba
06.6	9.8	Ba

200715b
RW Aquilae

1039.5	9.1	L
43.4	9.2	L
51.4	9.3	L
65.6	9.2	B
65.7	9.0	M
73.6	9.1	Ba
79.7	9.2	R
80.6	8.9	Ba
89.7	9.1	Ba
90.6	9.6	Bu
91.6.	9.1	B
92.6	8.9	Ba
92.7	8.9	R
93.6	8.8	M
94.6	9.1	Ba

RW Aquilae

J.D. 242	Obs.	Est.
1094.7	8.8	R
96.6	9.1	Ba
1100.6	9.0	Ba
01.6	9.2	Pi
01.6	9.1	Ba
04.6	9.1	Ba
06.6	9.1	Ba

200747
RX Cygni

1047.8	8.1	Mu
49.7	8.1	Mu
61.7	8.0	Mu
62.7	7.8	Mu
63.6	7.8	O
72.7	8.0	Mu
73.7	7.8	Mu
95.7	8.0	Mu

200812
RU Aquilae

1046.6	9.6	O
73.6	10.2	Ba
80.7	10.5	Ba
91.6	10.5	B
96.6	11.2	Ba
1106.6	11.5	Ba

200906
Z Aquilae

1051.8	12.7	E
65.6	10.2	B
73.6	9.4	Ba
80.6	9.6	Ba
91.6	9.0	B
96.7	9.8	Ba
1101.6	10.0	Nt
06.6	9.9	Ba

200906
R Sagittae

1042.8	9.4	R
65.6	9.9	B
65.7	9.7	M
73.6	9.3	Ba
79.7	9.5	R
80.6	8.9	Ba
89.6	8.8	Ba
90.6	8.7	Bu
91.6	9.0	B
92.6	8.8	Ba
93.6	8.7	M
94.6	8.8	Ba
96.6	8.8	Ba
1100.6	8.8	Ba
01.6	8.9	Ba
04.6	8.8	Ba
06.6	8.9	Ba

200938
RS Cygni

J.D. 242	Est.	Obs.
1018.4	7.4	L
43.4	7.5	L
48.7	7.7	Ma
62	9.0	ϒ
62.6	8.8	M
72.6	8.3	Ma
73.6	7.4	Ba
78.6	8.7	Ma
79.7	8.2	R
80.6	7.3	Ba
89.6	8.4	M
89.6	7.9	Ba
92.7	7.4	Ba
93.7	7.9	Ba
94.6	7.8	Ba
96.6	8.6	Wpi
96.6	8.7	Pi
96.6	8.9	Ma
96.6	7.9	Ba
1100.6	7.7	Ba
01.6	7.8	Ba
04.6	7.8	Ba
06.6	7.9	Ba

201008
R Delphini

1049.8	9.6	M
77.7	<11.0	Wh
80.6	12.5	Ba
93.7	<11.3	Wh
1105.7	<11.3	Wh

201130
SX Cygni

1051.8	10.3	E
71.9	10.6	E
78.7	9.9	Ba
85.6	9.8	M
89.6	10.2	Ba
92.6	10.2	B
1100.6	10.5	Ba
01.5	11.2	Pi
04.6	11.8	Nt

201121
RT Capricorni

1042.8	8.8	R
45.6	6.6	L
78.7	6.9	Ba
79.7	7.6	R
82.6	6.5	Ba
96.7	6.4	Ba
1101.6	7.4	Pi
07.6	6.6	Ba

201647
U Cygni

1045.6	< 9.8	Cr
47.8	10.0	Mu
49.7	10.1	Mu
50.6	9.6	Cr
51.4	10.3	L

VARIABLE STAR OBSERVATIONS July, August, September, 1916—Continued.

U Cygni

J.D.	Est.	Obs.
242		
1051.6	9.6	Cr
52.6	10.0	Wpi
52.6	9.7	Pi
52.6	9.8	Cr
59	<10.0	♈
62	<11.0	♈
62.7	10.1	Mu
64.6	< 9.8	Cr
67.6	7.7	M
72.7	10.9	Mu
73.6	9.3	Ba
78.6	<10.2	Cr
78.7	11.1	Mu
78.7	<10.3	R
81.6	<10.2	Cr
82.6	9.1	Ba
89.6	10.0	M
91.6	9.9	Cr
93.6	10.0	Cr
95.7	11.0	Mu
96.6	10.8	Wpi
96.6	10.4	Pi
98.6	10.2	M
1100.6	8.8	Ba

202539
RW Cygni

1042.7	8.4	R
48.7	8.3	Ma
51.6	8.0	Ma
52.6	8.0	Wpi
52.6	8.1	Pi
57.6	7.8	Ma
62.6	8.2	M
64.6	7.6	O
66.6	8.2	Ma
73.6	7.8	Ba
78.6	8.4	Ma
78.7	8.0	Bl
79.7	8.9	R
82.6	7.3	Ba
89.6	8.6	M
92.6	8.4	Ma
92.6	7.5	Sc
96.6	8.6	Wpi
96.6	8.6	Pi
96.6	8.3	Ma
97.7	8.3	Bl
1100.6	7.3	Ba
07.6	7.9	Ba

202817
Z Delphini

1049.7	9.6	M
51.8	9.5	E
52.7	9.0	V
66.7	9.5	V
73.6	9.9	Ba
81.7	9.7	V

Z Delphini

J.D.	Est.	Obs.
242		
1082.6	10.2	Ba
96.6	10.8	Ba
97.7	<11.5	V
1101.7	<11.2	Pi
05.6	11.7	Nt
06.6	11.5	Ba
07.7	11.5	M

202946
SZ Cygni

1006.4	9.6	L
18.4	9.6	L
42.7	10.0	R
44.7	10.3	R
46.6	9.5	Le
46.7	9.4	R
47.6	9.4	Le
47.7	9.3	R
48.7	9.3	Le
49.7	8.9	Le
50.6	8.8	Le
51.4	9.6	L
51.6	8.8	Le
52.6	9.3	Wpi
52.6	9.4	Pi
52.7	8.9	Le
54.8	9.0	Le
55.6	9.1	Le
5.66	9.4	Le
57.7	9.5	Le
58.7	9.6	Le
59.7	9.6	Le
60.6	9.7	Le
62.6	9.6	Le
63.6	9.0	Ba
63.7	9 1	Le
64.7	9.0	Le
65.6	9.0	Le
65.6	8.9	M
66.6	9.0	Le
67.6	9.2	Le
68.6	8.9	Ba
68.6	9.4	Le
68.7	9.2	R
69.6	9.4	Le
70.7	9.5	Le
71.7	9.7	R
72.7	9.4	R
72.7	9.8	Le
73.6	10.0	Ba
73.7	9.8	Le
74.7	9.9	R
74.7	9.8	Le
75.7	10.3	R
75.3	9.8	Le
77.6	9.2	Bl
77.7	9.4	Le
78.6	9.0	Ba
78.7	9.5	Bl

Z Delphini

J.D·	Est.	Obs.
242		
1178.7	9.4	Le
78.7	9.0	R
79.6	8.9	Le
79.7	8.9	R
80.6	8.8	Ba
82.6	8.8	Ba
82.8	9.3	E
84.7	9.3	Le
85.6	9.3	Le
88.6	9.3	Ba
89.6	9.7	Ba
89.6	10.0	M
89.7	9.9	Le
91.6	9.3	B
92.6	9.3	Ba
94.6	8.9	Ba
94.7	9.5	R
94.7	9.0	Le
95.7	8.7	Ba
95.8	8.8	Le
96.6	8.6	Ba
96.6	8.8	Le
97.7	9.5	Bl
97.8	9.0	Le
98.7	9.1	Le
99.7	9.2	Le
1100.6	9.2	Ba
00.6	9.4	Le
01.6	9.3	Ba
03.6	9.8	Le
04.5	9.4	Ba
04.8	9.9	Le
05.6	9.8	Le
06.6	9.4	Ba
06.7	9.8	Le
07.6	9.2	Ba
08.7	9.4	Le
09.7	8.9	Le
10.8	8.8	Le

202954
ST Cygni

1065.6	11.2	M
73.7	10.4	Ba
78.6	9.8	B
82.6	10.1	Ba
89.6	10.8	M
91.6	9.7	B
1100.6	9.8	Ba
01.6	10.1	Pi
05.6	10.4	Nt
07.6	9.8	Ba

203226
V Vulpeculae

1042.8	8.8	R
48.7	8.7	Ma
50	8.9	♈
51	8.9	♈
62	9.0	♈

V Vulpeculae

J.D.	Est.	Obs.
1063	8.9	♈
64	9.0	♈
66.7	8.8	Ma
67.7	9.2	M
73.7	8.7	Ba
82.6	8.6	Ba
85.6	8.8	M
92.7	9.2	R
93.6	8.9	Ma
99.6	9.2	Ma
1100.6	9.6	Ba
07.6	9.0	Ba

203611
Y Delphini

1049.7	11.7	M
51.8	<12.1	E
82.6	<13.0	Ba
98.6	13.1	B

203816
S Delphini

1049.8	10.7	M
1105.6	9.7	Nt
07.7	10.1	M

203847
V Cygni

1044.6	12.5	B
50.9	12.3	E
69.6	12.3	B
73.7	12.5	Ba
82.6	12.4	Ba
89.6	10.9	Ba
95.6	10.7	B
99.6	11.2	M
1100.6	11.0	Ba
05.6	12.7	Nt

204016
T Delphini

1049.8	10.0	M
51.8	10.0	E
73.7	9.9	Ba
78.6	9.9	B
82.6	10.2	Ba
92.6	10.0	B
94.7	10.5	R
96.6	10.9	Nt
1100.6	10.7	Ba
01.7	10.6	Pi
07.7	11.2	M

204318
V Delphini

1050.9	13.0	E
82.6	<12.6	Ba
98.6	<12.5	B

204415
U Capricorni

1105.6	<10.7	M

204405
T Aquarii

J.D.	Est.	Obs.
242		
1042.8	<10.5	R
51.8	<11.0	E
55.7	<12.2	Le
77.6	12.7	B
82.6	12.4	Ba
91:6	<11.0	Nt
94.6	<11.0	B
94.7	10.5	R
96.7	11.0	Ba
1106.6	10.4	Ba
07.7	10.4	Sp

204846
RZ Cygni

1082.6	12.6	Ba
1100.6	12.5	Ba

205017
X Delphini

1050.9	10.3	E
73,7	11.6	Ba
82.7	12.3	Ba
91.6	<11.4	Nt
95.6	12.8	B
96.7	12.6	Ba

205923
R Vulpeculae

1042.8	<10.2	R
49.7	12.0	M
51.9	10.5	E
82.7	9.5	Ba
85.6	9.5	M
89.6	9.6	Ba
96.7	8.7	Ba
1106.6	7.7	Ba

210116
RS Capricorni

1042.8	8.7	R
78.7	7.9	Ba
97.7	8.6	Bl
1100.6	7.7	Ba
01.6	8.2	Pi
05.7	8.2	M
07.6	8.0	Ba

210129
TW Cygni

1066.7	10.7	V
73.7	11.1	Ba
81.8	11.0	V
82.7	11.1	Ba
95.6	12.1	B
97.7	10.8	V
1100.6	11.7	Ba

VARIABLE STAR OBSERVATIONS July, August, September, 1916—Continued.

210868 T Cephei

J.D.	Est.	Obs.
242		
1006.4	10.6	L
39.4	10.2	L
42.8	10.5	R
51.4	9.8	L
55.6	9.4	Le
61.6	9.9	O
72.6	9.8	M
73.7	8.6	Ba
74.7	9.4	Ma
78.6	9.4	Ma
78.6	9.1	S
91.6	9.3	Bu
92.6	8.4	Sc
93.6	8.3	B
93.6	8.8	M
94.6	9.0	Ma
97.7	8.8	Bl
99.6	8.7	Ma
1100.6	8.0	Ba
04.6	9.0	Wh
07.7	8.7	Nt
10.5	8.8	O

211614 X Pegasi

1078.7	11.0	Ba
1100.6	10.4	Ba
07.6	10.1	Ba

211615 T Capricorni

1078.7	<12.7	Ba
1100.6	<12.8	Ba

213044 W Cygni

1006.4	5.7	L
18.4	5.4	L
28.4	5.4	L
39.5	5.5	L
45.5	5.5	L
51.4	5.4	L
51.6	5.4	Le
64.8	6.3	Lu
65.8	6.2	Lu
66.8	6.3	Lu

213678 S Cephei

1052.7	10.6	Le
72.6	10.8	M
73.7	9.7	Ba
93.6	10.0	B
93.6	11.2	M
99.6	11.5	M
1100.6	11.3	Ba

213753 RU Cygni

1042.8	8.4	R
65.6	7.8	M
73.7	7.3	M
82.6	7.8	M
1101.6	7.5	Ba

213843 SS Cygni

J.D.	Est.	Obs.
242		
1006.4	11.8	L
08.4	11.9	L
18.4	11.8	L
28.4	8.2	L
39.5	9.8	L
41.4	10.4	L
42.7	10.8	R
43.4	11.0	L
44.7	10.9	R
45.5	11.0	L
44.6	11.2	Cr
45.7	11.4	B
46.7	11.6	R
47.6	11.6	Le
47.7	10.7	M
47.7	11.1	R
47.8	11.8	E
48.8	11.8	E
49.7	11.0	M
50	11.4	ϒ
50.6	11.5	Cr
50.8	11.4	M
51	11.4	ϒ
51.4	11.6	L
51.6	11.3	Wh
51.6	11.5	Cr
51.7	11.9	Le
51.7	11.6	Pi
51.8	11.8	E
52.6	11.8	Cr
52.7	11.6	Pi
52.7	11.8	Le
52.8	<11.3	V
54.8	11.8	Le
55.6	11.8	Le
56.6	11.6	Bu
58.6	11.6	Bu
58.7	11.8	Le
59.6	11.7	Bu
60.6	11.6	Bu
60.7	11.8	Le
62	11.4	ϒ
62.6	10.8	Le
62.6	11.0	M
62.7	11.7	B
63	11.4	ϒ
63.6	10.6	B
63.6	10.7	Ba
63.7	10.5	Le
64	8.3	ϒ
64.6	8.3	Nt
64.6	8.4	M
64.6	8.3	O
64.6	8.4	Cr
64.6	9.0	B
64.6	8.6	Bu
64.7	8.3	Le
65.6	8.3	Nt
65.6	8.6	B

SS Cygni

J.D.	Est.	Obs.
242		
1065.6	8.3	B
65.6	8.3	M
66.6	8.4	Le
66.6	8.4	Ma
66.7	8.5	V
67.6	8.3	M
67.6	8.4	Le
68.6	8.6	M
68.6	8.9	Ba
68.6	8.5	Le
68.7	9.0	R
68.9	9.2	E
69.6	9.1	Sc
69.6	9.1	B
69.6	8.9	Le
69.7	9.4	V
69.9	9.3	E
70.7	9.5	Le
70.7	9.6	V
70.8	9.3	M
70.9	9.5	E
71.6	9.7	M
71.6	9.7	V
71.7	9.2	R
71.9	9.5	E
72.6	10.0	M
72.7	10.2	Le
72.7	9.4	R
73.6	10.2	Wh
73.6	10.6	Ba
73.7	10.7	Pi
73.7	10.2	M
73.7	10.3	Le
74.6	10.4	M
74.7	10.1	R
74.7	10.6	Le
75.7	10.9	R
76.7	11.5	Sc
77.6	11.7	Ba
77.6	11.9	B
77.6	<9.6	S
77.6	<11.0	Cr
77.6	11.9	Bu
77.7	11.8	Le
78.6	11.6	Ba
78.6	12.0	B
78.6	<9.6	S
78.6	12.0	Cr
78.7	11.8	Le
78.7	11.5	R
78.7	10.8	M
79.7	10.8	R
79.7	11.8	Le
80.6	11.7	Ba
80.6	11.8	Cr
80.6	<12.1	Sc
81.6	11.8	Cr
82.6	11.6	Ba
82.7	11.8	Le

SS Cygni

J.D.	Est.	Obs.
242		
1082.8	11.0	E
83.6	11.0	M
84.7	11.8	Le
87.6	<11.0	Cr
87.6	<11.4	Nt
88.6	11.7	Ba
89.6	11.6	Ba
91.6	11.1	Nt
91.6	11.1	Cr
91.6	11.1	Bu
91.6	11.1	B
91.6	<9.6	S
92.6	11.0	Nt
92.6	10.6	B
92.6	10.9	Cr
92.6	11.0	Sc
92.7	11.1	Ba
92.7	10.9	R
92.9	10.7	E
93.6	11.1	Bu
93.6	10.7	B
93.6	11.0	M
93.6	11.0	V
93.6	10.7	Cr
93.7	<11.3	Wh
93.7	10.9	Ba
94.6	10.8	Nt
94.6	10.6	B
94.6	10.6	M
94.6	10.7	Ba
94.6	<9.6	S
94.6	11.0	V
94.7	10.6	R
95.6	10.8	Nt
95.6	11.1	Bu
95.6	11.1	V
95.6	10.5	Sc
95.6	10.6	B
95.7	10.8	Ba
96.6	9.9	Nt
96.6	9.8	Bu
96.6	9.2	Wpi
96.6	9.8	Pi
96.6	9.5	B
96.6	9.7	Ba
96.6	9.6	Le
96.8	9.1	M
97.6	8.4	Bu
97.6	8.6	S
97.6	8.4	M
97.6	8.5	Ma
97.6	9.0	B
97.7	8.7	Le
98.6	8.7	B
98.6	8.3	Pi
98.6	8.2	M
98.6	8.1	Nt
98.7	8.4	Le
98.8	8.7	E
99.6	8.6	Ma

SS Cygni

J.D.	Est.	Obs.
242		
1099.6	8.3	M
99.7	8.6	Le
1100.6	8.5	L
00.6	8.6	Ba
00.6	8.3	S
00.8	8.6	E
01.5	8.2	Pi
01.5	8.5	Ba
01.5	8.3	Cr
01.6	8.5	Ma
01.6	8.6	B
01.6	8.2	Nt
02.6	8.3	Ma
02.6	8.2	Cr
02.6	8.1	Bu
03.6	8.5	Le
04.5	8.5	Ba
04.6	8.2	Nt
04.6	8.3	M
04.6	8.3	S
04.6	8.6	Wh
04.6	8.7	B
04.6	8.6	Sc
04.6	8.3	Cr
04.7	8.6	Le
05.6	8.4	Le
05.6	8.2	Nt
05.6	8.9	B
05.6	8.4	M
06.6	8.2	Nt
06.6	8.3	Bu
06.6	8.8	B
06.6	8.6	Ba
06.6	8.3	Cr
06.7	8.7	O
06.7	8.5	Le
07.5	8.2	Nt
07.6	8.8	B
07.6	8.6	Ba
07.6	8.5	M
07.6	8.3	Cr
09.6	8.7	M
09.6	8.7	O
09.7	8.7	Le
10.5	8.8	O
10.6	8.8	M
11.5	8.7	O

213937 RV Cygni

1018.4	6.3	L
19.8	6.5	Le
43.4	6.4	L
47.4	7.7	R
47.7	6.3	Le
51.6	6.9	Ma
59	7.8	ϒ
62	8.0	ϒ
62.6	7.8	M
65.7	6.3	Le
66.6	6.8	Ma

VARIABLE STAR OBSERVATIONS July, August, September, 1916—Continued.

J.D.	Est.	Obs.
RW Cygni		
242		
1073.7	6.6	Ba
74.7	6.3	Le
78.6	7.4	Ma
82.6	7.7	M
83.6	7.0	Ma
89.6	6.4	Ba
97.6	7.2	Ma
1100.6	6.6	Ba
214024		
RR Pegasi		
1047.8	10.9	E
73.7	12.5	Ba
1106.6	<13.4	Ba
07.6	13.6	B
215605		
V Pegasi		
1051.8	13.0	E
73.8	<10.8	M
1105.7	<13.8	Sp
06.6	<13.2	B
06.6	<13.0	Ba
215934		
RT Pegasi		
1052.8	10.7	V
69.7	10.9	V
73.7	11.2	Ba
81.8	<11.1	V
97.7	<11.3	V
1106.6	11.1	Ba
220412		
T Pegasi		
10956	11.5	Bu
01.6	12.5	Ba
05.6	13.4	B

J.D.	Obs.	Est.
220613		
Y Pegasi		
242		
1105.6	10.4	B
220714		
RS Pegasi		
1105.6	12.3	B
222439		
S Lacertae		
1073.7	10.9	Ba
73.8	10.9	M
89.6	11.6	Ba
1100.7	12.1	Ba
11.5	<10.4	O
225120		
S Aquarii		
1073.7	8.6	Ba
97.7	7.8	Bl
1100.7	7.8	Ba
07.7	8.4	M
225914		
RW Pegasi		
1069.8	10.1	V
73.7	10.2	M
73.7	9.8	Ba
81.8	10.1	V
85.6	10.0	M
89.6	9.5	Ba
95.6	9.9	Bu
97.8	10.1	V
1100.7	9.6	Ba
01.7	10.2	Pi
05.6	10.3	B
06.6	10.2	Bu
07.7	9.9	Sp

J.D.	Est.	Obs.
230110		
R Pegasi		
242		
1051.7	<10.6	Pi
54.8	<12.1	E
78.7	12.7	Ba
95.7	<10.1	Sc
1101.6	<12.5	Ba
05.7	11.0	Wh
230759		
V Cassiop		
1042.8	8.8	R
49.8	8.8	E
50.8	9.0	M
51.7	9.0	Pi
77.7	9.7	Sp
77.7	9.8	B
78.7	10.1	Mu
78.7	10.0	Ba
92.6	10.3	B
92.7	10.7	Sc
95.7	10.7	Mu
1100.7	11.0	Ba
05.7	:11.0	M
07.6	11.4	Ba
231425		
W Pegasi		
1049.8	9.2	M
54.8	9.7	E
69.8	9.9	V
81.8	10.9	V
85.6	9.3	M
89.6	9.8	Ba
97.8	10.3	V
1100.7	10.4	Ba

J.D.	Est.	Obs.
231508		
S Pegasi		
242		
1054.8	10.2	E
73.8	10.0	M
78.7	10.4	Ba
1101.6	11.0	Ba
05.6	11.1	B
05.6	10.6	M
233335		
ST Androm.		
1047.8	8.9	E
50.8	9.1	M
68.7	9.1	Ba
78.6	9.0	Wpi
78.6	8.9	Pi
78.7	8.7	Ba
89.6	8.5	Ba
94.6	9.3	S
95.6	9.4	Bu
99.8	9.4	M
1100.7	8.9	Ba
07.6	9.0	B
09.6	9.3	O
233815		
R Aquarii		
1049.9	9.4	E
78.7	8.0	Ba
1106.6	6.3	Ba
07.7	7.0	M
233956		
Z Cassiop.		
1047.8	9.9	E
50.8	9.7	M
54.8	9.7	E
78.7	9.9	Ba

J.D.	Est.	Obs.
Z Cassiop.		
242		
1089.7	10.0	Ba
1101.6	10.9	Ba
235209		
V Ceti		
1078.7	10.1	Ba
95.7	9.3	Ba
1106.6	9.5	Ba
235350		
R Cassiop.		
1047.9	12.6	E
50.8	10.7	M
77.7	12.9	B
94.8	12.9	B
1107.6	13.0	Ba
235525		
Z Pegasi		
1049.8	8.8	M
69.8	<11.3	V
81.8	<11.3	V
1101.6	10.7	Ba
11.6	10.6	O
235939		
SV Androm.		
1049.9	9.5	E
50.8	8.0	M
77.7	10.4	Sp
78.6	10.1	Pi
78.7	9.8	Sp
78.7	10.1	Ba
89.7	10.6	Ba
1101.6	11.0	Ba
07.6	11.0	B

	July-Aug.	July-Aug.
No. of observations	1049	1452
No. of stars observed	170	196
No. of observers	21	22

It is a pleasure to note Mr. F. C. Leonard's return to the ranks of active observers. Mr. Leonard recently received an election to the Royal Astronomical Society.

The congratulations of the Association were sent to Professor E. C. Pickering, Director of the Harvard College Observatory, on the occasion of his birthday, for which a cordial note of thanks was received by the Secretary.

The September issue of the "Monthly Evening Sky Map" contains an able article on Variable star observing by Mr. D. B. Pickering which well describes our methods and aims. Mr. Pickering recently observed the asteroid Eunomia on the field of the Variable 230110 R Pegasi. Mr. Campbell observed it with the photometer and noted a variation of .5 of a magnitude in three hours.

Dr. Gray, who now visits the Southern Hemisphere frequently, has been observing a number of neglected variables that are too far south for us to observe.

Mr. Bancroft's highly commendable list of 482 observations of 168 Variables which he contributes this month is the best that the secretary has received, and speaks well for Mr. Bancroft's interest and zeal. It is a record to be proud of as well as a valuable contribution to science.

The recent rise of the variable 213843 SS Cygni was exceedingly well observed. One hundred and twenty observations of this variable were made in an interval of seventy-two days, which indicates what can be accomplished by coöperation when we wish to concentrate attention on any particular star.

One of the many interesting features of this report is the indicated rise of the Variable *184205* R Scuti, which was particularly well observed by Messrs. Bancroft, Burbeck, and Mach. The latter is deserving of great credit for his really wonderful work with a 2″ glass. He contributes a list of sixty-five observations this month, which is a good record for observers with a 3″ refractor.

Mr. Eaton was a fortunate observer of the recent occultation of Saturn, and the thanks of the Association are due him and Mr. McAteer for their early morning observations which are of special value.

The following calculated dates of maxima are cited from the "Companion to the Observatory."

Sept.	3	*085008*	T Hydrae	Oct.	2	070112	R Geminorum
	10	160625	RU Herculis		2	084803	S Hydrae
	14	183308	X Ophiuchi		9	021024	R Arietis
	27	195849	Z Cygni		18	194048	RT Cygni
					21	103769	R Urs. Maj.
					21	123961	S Urs. Maj.

To facilitate the work of the Secretay it is very important that lists of observations should reach him by the first day of each month. Will members kindly comply with this request in the future.

The following members contributed to this report:—Messrs. Baldwin, Bancroft, Bouton, Burbeck, Crane, de Perrot, Eaton, Gray, Gregory, Hunter, Lacchini, Leonard, Mach, McAteer, Mundt, Nolte, Olcott, D. Pickering, W. Pickering, Richter, Schulmaier, Spinney, Vrooman, Whitehorn, Yendell, Miss Ludeke, and Miss Swartz.

William Tyler Olcott,
Corresponding Sec'y.

Norwich, Conn.
Sept. 10, 1916.

COMMUNICATIONS.

A Correction.—Will you pardon me if I call your attention to a little slip of the pen on p. 446 of the Aug.-Sept. Popular Astronomy? It occurs in the interesting translation of Flammarion's article on the "Advance of the Legal Hour." where he says: "The active existence of governments, of offices, occurs between 8 o'clock in the morning and 6 o'clock at night......the centre of which is not the noon, but *an hour*." The last two words were, I presume, inadvertently substituted for "one o'clock." The French expression, "*une heure*" admits of the double rendering.

Edith R. Wilson.

A Very Unusual Aurora was observed at Alma a few nights ago and since like phenomena may have been observed elsewhere, I am enclosing notes taken at the time which you may use if you care to.

August 26. 10:45 to 10:55 Standard time. At this particular time the phenomena had the appearance described as follows: Magnificent auroral streamers covered the sky, rapid in movement from east to west. The streamers were as much as 90° in length, some of them, and were particularly bright near the zenith and higher altitudes.

Appearance at 10:45: Jupiter was at an altitude of 40 degrees. Streamers came apparently from the direction of this planet. A long dark space between the streamers extended east and west across the sky, gradually broadening toward the west, the taper being near the planet. The zenith was particularly brilliant with momentarily bright clouds of this streamer substance. One could fancy such an effect being produced by rapid motion through rare matter.

The night was cool and there was a little wind. The sky was hazy, only the brighter stars being visible. There were occasional patches of small scattered clouds.

Auroras have been very frequently observed in this locality during the past year.

CHARLES A. MANEY

Alma, Mich. Sept. 4, 1916.

Planetary Conjunctions.—I enclose a list of some observations of Venus and Jupiter which I thought might be of interest.

I read the article of Dr. Dawson in the June-July Number and that prompted me to send the enclosed taken from my record book.

I am too old now to do much work at night, but keep watch of comets and sunspots yet, in a general way.

OBSERVATIONS OF PLANETS IN CONJUNCTION.

Dec. 20 1881	Neptune and Jupiter	in field low power
July 20 1883	Mercury and "	40′ apart
" 26 1883	Venus and "	10′ "
" 17 1885	Mercury and Venus	22′ "
Aug. 5 1885	Venus and Jupiter	35′ "
" 8 1886	" and Saturn	1′ "
	Venus seen. Saturn not seen. They were about 2^h west of ⊙	
Oct. 13 1908	Venus and Jupiter	20′ apart
" 28 1910	" and "	10′ "
	Jupiter not seen; only 8° from ⊙; but Venus seen.	

These were observed in a 5′ Clark Telescope. The notes were taken from my observing book. *Some* were early morning observations.

JOHN R. HOOPER.

A More Favorable Public Opinion.—In the May number of POPULAR ASTRONOMY, Mr. Bigelow has stated that the "Greatest need of astronomy is a more favorable public opinion." I wish to point out some causes for the lack of interest in astronomy, and to mention some efforts for improvement.

It is so much more natural for people to look down than up that Galileo in his time deplored the general indifference to the stars. It is small wonder that the ignorance has not been lessened in our modern electric lighted life. A city dweller knows no lights above flaring advertisements; and when a planet succeeds in attracting his eyes, he concludes that it is an airship. If he goes into the country, he either rides in a brightly lighted trolley car, or in an automobile which holds his attention on the lighted road in front.

In the past, universities taught astronomy to only a few mathematically gifted students. Ordinary people, although they might be acquainted with the stars, did not dream of studying astronomy. But now, the more progressive colleges offer courses in which any student capable of doing college work may get a clear comprehension of astronomical phenomena; may become familiar with stars; and see the planets and some clusters and a few nebulæ through a telescope. In the best courses, laboratory work with globes, photographs and other apparatus supplements the out-door observations. Nevertheless, the fear of astronomy as a too mathematical subject is still prevalent; and the prejudice against it is increased by the modern demand for educational subjects of practical value. Studies are ordinarily divided into two distinct classes in which the humanities comprise the cultural group; sciences and industries, the utilitarian. By this classification, astronomy, being a science, is not placed in the cultural group, and as relatively few people need any knowledge of astronomy in their business, it is not generally practical. Therefore, being regarded as useless, it is seldom offered in secondary schools and is elected by small numbers in the colleges. As a result, there are few even among college graduates who ever notice the stars or can explain simple astronomical phenomena.

It is a mistake to blame the research observatories for the public's ignorance. For although their business is not primarily instruction, they do teach both directly and indirectly. In the June number of POPULAR ASTRONOMY, Mr. Brashear has described the valuable educational work of the Allegheny Observatory. Lick Observatory is open to visitors every Saturday evening; they may look through both the twelve-inch and the great thirty-six inch refractors; and astronomers explain the beautiful glass photographs of celestial objects. The Yerkes Observatory gives popular lectures twice a week which are enthusiastically attended by hundreds of people. Moreover, the results of the investigations of all the great observatories are available not only to professional astronomers, but to the public through popular books and magazines. Some of the greatest astronomers have written successfully for the public. Besides the large observatories, there are many smaller ones belonging to cities, colleges, and societies, which are open to visitors either by appointment or on certain evenings of the week or month.

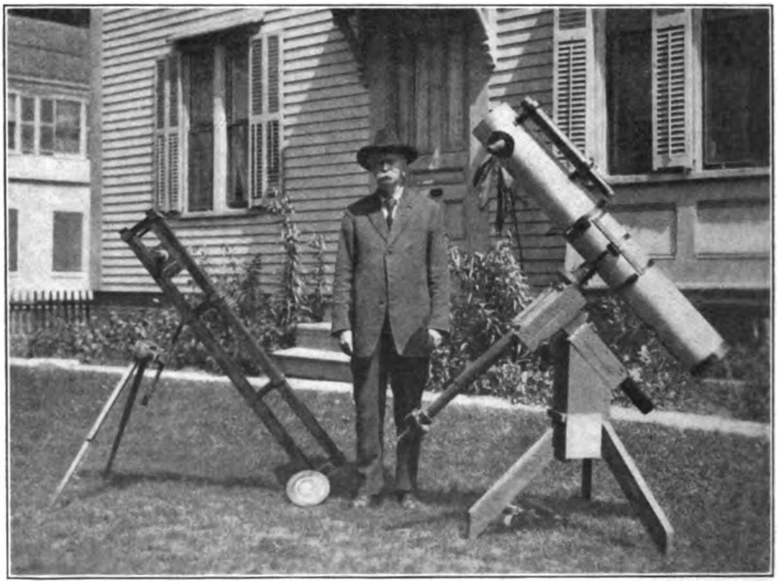
All these efforts help to inspire interest in astronomy; but a visit to an observatory or an astronomical lecture will not teach a person to know the stars. Merely pointing out stars once or twice or showing them through a telescope does not suffice. In order to recognize the same stars in different parts of the sky, frequent observations are required for at least a whole year. The extension lectures and summer school courses in popular Astronomy given by some universities are appreciated by a variety of people. Doubtless a greatly increased number of such courses would be profitable to many people.

Nevertheless, relatively few grown people will take the trouble necessary to become familiar with the stars; but children are eager to learn; they have not acquired the habit of always looking down and have not become resigned to conventional ignorance. Scout and similar organizations help rouse interest in astronomy. For although the required knowledge of the stars is necessarily extremely limited, honors are offered to induce boys or girls to learn the constellations and facts about the bright stars. Time is well spent in helping groups of boys and girls win their honors in astronomy; for children who learn to love the stars will always use every opportunity to learn more about them. As such children grow up, they will know how to look and think beyond the limits of our own little planet.

LEAH B. ALLEN.

Whitin Observatory.
Wellesley College.

A Home-made Telescope.—I am sending you a photograph of my reflectors. The one with the equatorial mounting was built by myself. The mirror is 6″ in diameter and of 53″ focus. The mounting is rather rough, as I had to use any material I could find. I was helped by Mr. Mellish of Cottage Grove, Wis., and Mr. Hassard of Toronto, Canada. The one with the wooden tube was made for me by Mr. E. C. Gray of North Jay, Maine. It is of 60″ focus and 6″ diameter. I use it to observe the sun.



MR. WELCH AND HIS TELESCOPES.

On the morning of August 25 I observed the occultation of Saturn with my equatorial. It was a fine sight and the first time that I ever had a chance to see Saturn occulted. I made the immersion about $3^h\ 16^m$; the emersion $4^h\ 19^m$.

FRANK H. WELCH.

14 Bank St. Brunswick, Maine.

GENERAL NOTES.

We had expected to give a brief account of the August meeting of the American Astronomical Society in this number of POPULAR ASTRONOMY but the copy had not reached us at the time the forms had to be locked up for the press. This account and some of the abstracts of papers will appear in our next number.

If the tabular matter in this issue seems out of proportion to the popular matter please notice that we have added an extra eight pages in order to include all that we thought should be printed at once.

Dr. Percival Lowell and Professor Frank Schlesinger have recently been elected honorary fellows of the Royal Astronomical Society of Canada,

Mr. Edward F. Bigelow, Editor of the *Guide to Nature* has been elected "Scout Naturalist" for the "Boy Scouts of America," and will endeavor to interest the boys in astronomy through a department "On Nature's Trail" in the magazine *Boy's Life.*

Variable Nebula.—At the August meeting of the Royal Astronomical Society in London Mr. H. Knox-Shaw, of the Helwân Observatory, exhibited lantern slides of photographs of the nebula N. G. C. 6726 attached to the variable star R Coronae Australis, which showed that the nebula itself varies in shape as well as in brightness. The period of variation appears to be very irregular.

Spectrum of Comet *a* 1915 (Mellish).—The Bulletin No. 74 of the Lowell Observatory, issued August 1916 gives the results of the study of the spectrum of comet *a* 1915, discovered by Mellish. A plate is given showing reproductions of photographs of the spectrum of this comet and that of comet *b* 1914 (Zlatinsky). The two spectra are in general very much alike, but certain of the bands are closer together in the spectrum of Mellish's comet than in that of Zlatinsky's comet, The carbon and cyanogen bands were strong in both. The continuous spectrum was much stronger in Mellish's comet which did not approach so close to the sun as did Zlatinsky's comet.

Large Telescope Built by Students.—In the *Scientific American* for September 9, 1916, is given a brief account of a large telescope which has been built during the past seven or eight years by the students in the engineering department of the state university of Lincoln, Nebraska. "The telescope is eighteen feet long and will require an observatory dome twenty-six feet in diameter. It is equipped with a twelve-inch lens, donated by a friend of the university. To have purchased the instrument from a factory would have cost in the neighborhood of $6,000. As it is the university has secured it at an expenditure of only a very small part of that sum."

Cincinnati Observatory.—Publications of the Cincinnati Observatory No. 18, just received, contains Part II of the Catalogue of Proper Motion Stars. This part includes the stars from 6^h to 15^h of right ascension.

Interference Measurements of Wave Lengths in the Iron Spectrum.—The Bureau of Standards has just issued a pamphlet containing the results of measurements of wave lengths in the Iron spectrum by Messrs. Keivin Burns, W. F. Meggers and Paul W. Merrill. Between the limits 3233 A and 6750 A some 400 lines were either remeasured or measured for the first time by the interference method. The greater part of the wave lengths were measured by means of three interferometers, the order of interference ranging from 20000 to 50000 in the case of each line. The work appears to have been of a very high degree of accuracy, the mean difference between these observations and the international standards being about one part in four million.

Photographic Observations of Seven Circumpolar Variables.—Volume 84, No. 1, of the Annals of Harvard College Observatory gives the results of the examination of the photographic records of the brightness of the seven circumpolar variables, T Cassiopeiae, R Aurigae, R Lyncis, R Ursae Majoris, T Ursae Majoris, RS Ursae Majoris and S Ursae Majoris. These are all long period variables, with light curves that are somewhat irregular. Samples of the light curves, both photographic and visual are shown in an excellent plate. The observed photographic magnitudes are printed for the whole period covered by the photographs, about 30 years. The observations were made under the direction of Miss Henrietta S Leavitt by Miss G. F. Mathews and Miss Susan Raymond, both of whom were holders of the Maria Mitchell Fellowship.

On the Spectrum of the Nebula about Rho Ophiuchi.—An exposure was made for the spectrum of the ρ *Ophiuchi* nebula on the nights of June 29, 30, July 1, 2, 3, and 4, 1916, with a single-prism spectrograph of high light-power, the total exposure amounting to twenty hours. A simple lens of 200^{mm} focus was used in front of the slit. The slit-width was 1^{mm}, but as the prismatic dispersion was considerable and the collimator focus six times that of the camera the spectrum has a length forty times the equivalent slit-width and thus fair purity for such cases. The light of ρ *Ophiuchi* entered the slit and its spectrum appears on the plate with a faint spectrum at either side attributed to the nebula. The nebular spectrum resembles and so far as can be judged is a duplicate of the spectrum of the star. No traces are present of the bright lines characteristic of the gaseous nebulæ. although owing to the concentration of its light in a few lines the spectrum of such a nebula would photograph in much less time than that of a nebula whose spectrum is continuous.

Excellent photographs of this nebula by Professor Barnard are reproduced in *Lick Observatory Publications*, Vol. XI and also in POPULAR ASTRONOMY, Vol. V, page 227. Judging from the exposures Barnard gave these plates it appears that with the somewhat more rapid plates available now the Willard lens would probably give a satisfactory negative of the nebula in four hours or less. Probably about one-fifth of the effective photographic light of a gaseous nebula is generally concentrated in the hydrogen line $H\gamma$. This would thus indicate an exposure of twenty hours with a spectrograph having a camera of the speed of the Willard lens, but the spectrographic camera used in this case has about seven times that speed. Hence after allowing for some loss of light in the prism the spectrum exposure of twenty hours should have given a good record of the spectrum if of the bright line type, and sufficient to give a weak record if the spectrum be continuous. This plate shows the latter type. Care was of course exercised to avoid twilight and moonlight.

Thus it appears that the spectrum of this nebula is continuous and as far as can be judged from this weak plate it is like that of the star *ρ Ophiuchi* about which the nebula clusters. A longer exposure spectrogram employing a somewhat larger lens before the spectrograph should give a better analysis of the spectrum. The indications are that this nebula is shining by reflected light as was here found to be true of the nebula in the Pleiades. In both these regions of the sky faint stars are conspicuously deficient in numbers. The type of spectrum conforms to the view that the scarcity of stars in these and certain other regions is due to light absorption of nebulæ which may otherwise be invisible.

V. M. SLIPHER.

Lowell Observatory, Bulletin 75.
July, 1916.

Spectrographic Observation of Barnard's High Proper Motion Star.—Spectrographic observations of the 11th magnitude star, recently discovered by Barnard to have an exceptionally large proper motion, show it to possess a spectrum closely resembling that of the red star *δ Virginis*. The spectrum belongs to the *Ma* class which includes those of the well known red stars Antares and Betelgeuse.

The velocity of the star in the line of sight is only moderate, measures for which indicate an approach of something like forty kilometers per second.

V. M. SLIPHER.

Lowell Observatory, Bulletin 75.
Flagstaff, Arizona.

The Mundane System in the time of Louis XIV.

NOTE:—The following is a translation of an article by the great French astronomer, Camille Flammarion; an article that seems to its translator well worth publication in POPULAR ASTRONOMY. It appeared in 1914 in the Bulletin de la Société Astronomique de France.

CHARLES NEVERS HOLMES.

Hotel Nottingham,
Boston, Mass.

"The age of Louis XI is of yesterday. We are still near enough to it. I have related in my *Mémoires* that at the beginning of my career, in 1863, I was acquainted with the nephew of Montgolfier, Marc Seguin the *ingénieur*, proprietor of the *Cosmos*, of which I was astronomical editor, and that with relation to this celebrated family I know I was contemporary with Madame Montgolfier, wife of the same inventor, for she only died in 1845, when I was three years old. It is true that she lived one hundred and eleven years, which is rare; but, all the same, I reach through her to the year 1734. Louis XIV having left this world in 1715, one sees that a human being with whom the men of my generation have been contemporary, born for example towards 1830, has been able easily to be acquainted with people having seen Louis XIV. There is then only a single intermediary between the grand monarch and ourselves, and this intermediary need not have been a centenarian as Madame Montgolfier.

"Ah well, in that time which dates from yesterday, men still believed the Earth was the center and the object of Creation, and the mundane system taught at the Sorbonne and at the Collège de France was that which the following figure places before our eyes.

"This figure is taken from the work of Gassendi, *Institutio Astronomica*, of which all scientific bibliophilists possess several editions in their library. This one is of 1656. All of the astronomical treatises of the 17th century show this representation of the universe. Our globe is in the center, immovable, having two fundamental elements, earth and water, continents and seas, surrounded by two other higher elements, air and fire. Around us there move, in the order drawn: the Moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn, in seven *cieux* or seven movable celestial spheres. Above there is the firmament of the fixed stars. Still farther, two crystalline *cieux*. Finally, the Primier Mobile, which imparts the movement to all the universe, and, farther away, in the outside space, the immovable CIEL EMPYRÉE, abode of God, of the angels and of the elect.

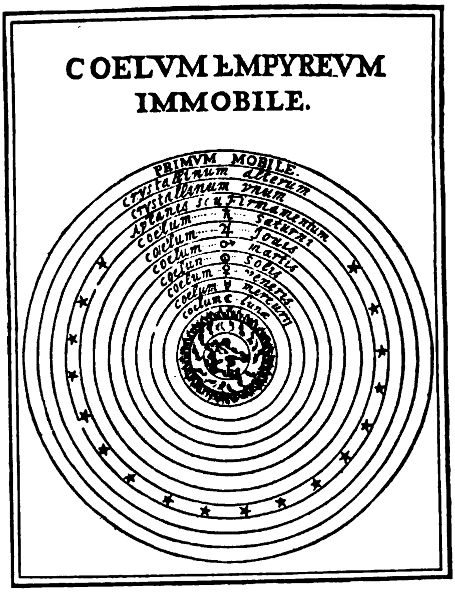


FIG. 1. THE SYSTEM OF THE WORLD AT THE TIME OF LOUIS XIV.

"This was very simple from the philosophical view-point; but it was extremely complicated astronomically, for it was truly impossible to explain the movementsof celestial bodies.

"Such was the usual opinion. The *Pensées de Pascal* commence thus: 'That man may contemplate all nature in her high and full majesty; that he may remove his eyes from the mean objects which surround him; that he may view this brilliant light *placed as an eternal lamp to illuminate the universe*; that the Earth may appear to him as a point *in comparison with the vast revolution that this star describes.*'

"Bossuet, Fénelon, all the educators had the same opinion. The Earth is immovable at the center of the universe, the Sun has been created to light the Earth and to turn around her in twenty four hours. The planets and the stars.turn likewise around us. The system of the moral world has for foundation this system of the physical world. This is the biblical and Christian *creation* of the Fathers of the Church. The condemnation of the Copernican theory, supported by Galileo, is in 1633. One recognizes in it the words: 'That the Sun should be at the center of the world and relatively immovable is an absurd and false proposition in philosophy, and actually heretical because it is expressly contrary to the Holy Scripture.'

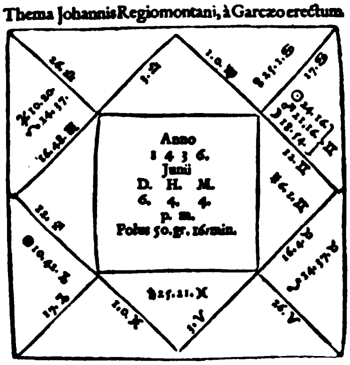


FIG. 2. THE HOROSCOPE OF REGIOMONTANUS.

"This text had the force of law for a long time. Descartes, for his peace of mind, threw into the fire the work he had written on astronomy. The liberal minds recognized the evident superiority of the Copernican hypothesis over the ancient theory; but it was forbidden them to proclaim it. Morin, professor of astronomy at the Collège de France, was an astrologer and told the horoscope of Louis XIV to Saint Germain, the day of his birth (September 5th, 1638). These horoscopes are not different from those of the 15th or the 16th centuries of which we have a specimen here concerning Régiomontanus, the classical horoscope calculated by Garcoeus on the subject of violent deaths.

"Régiomontanus is born, as is evident, on the 6th of June 1436, at 4h 4m in the afternoon, in the latitude 50° 16′, under the indicated astral positions.

"In all the cosmic treatises of the 15th, 16th, and 17th centuries, one finds figures analogous to those which we reproduce here, extracts of the first classical printed works. The hypothesis of Tycho Brahé made a light diversion from 1580 to 1600; but it was not lasting, and Ptolemy alone remained opposing Copernicus, the former being dominant. At the foundation of the Observatory of Paris (1672), people were still divided, and the Sorbonne did not wish to yield,

"With regard to this, it is perhaps not without interest to recall here the singular cosmic system imagined by Milton in his noble poem of Paradise Lost, written from 1658 to 1667. One may gain an idea of it from the facsimile reproduced here from *Milton's Astronomy* by Thomas N. Orchard (Longmans, 1913). As we see it, hell is at the bottom, heaven on high, chaos extends between hell and heaven a causeway is drawn as far as the Earth, the center of the celestial spheres. A spherical shell surrounds the physical universe.

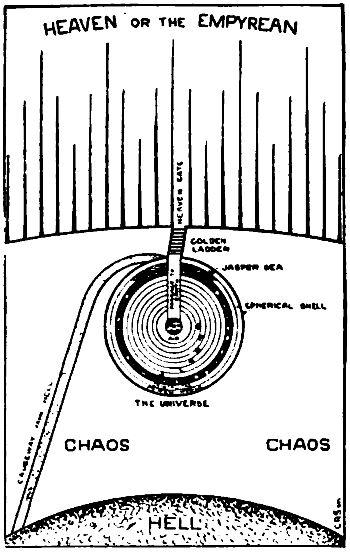


FIG. 3. THE COSMOGRAPHIC SYSTEM OF MILTON'S "PARADISE LOST."

"Science has advanced. To uphold today the text invoked by the judges of Galileo, would be to maintain that the Sun, 1,300,000 times of more volume than the Earth and 333,400 times heavier, turns around this point with the velocity of 10,870,000 meters per second, in order to describe each day a circle of 939 millions of kilometers in circumference around this small point declared fixed by the primitive legend *Terra in aeternum stat*! and contrary to all the laws of mechanics as to those of good sense.

"Galileo died in 1642, at the age of 78 years, in an unpretentious dwelling from which it was forbidden him to go out on any pretext, where he remained eight years a prisoner, and where he drew his last breath.

"He was an exile from human society. It was forbidden him, under penalty of the rigors of the Inquisition, to declare to whomsoever it might be his ideas on the movement of the Earth, and he was obliged to recite three times every week the seven psalms of penance as a punishment for his pride. A final ordeal was reserved for him, that of losing his sight, for him whose eyes had made such discoveries and who had shed light over human minds! He died on the 19th of January, 1642, in a room which we can still see today. This house has been religiously kept as it was in the time of the great *rénovateur*. It is there that he received, in the summer of 1638, the visit from the poet Milton, then in his thirtieth year. We can think that the Florentine astronomer remained silent regarding the Copernican truth and left his caller in Ptolemaic error. He had risked too much!

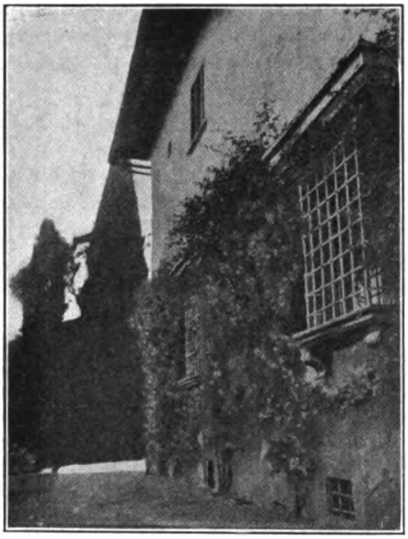


Fig. 4. The House in which Galileo Died.

"I never go to Florence without making a pilgrimage to this pleasant dwelling, to this noble home of persecuted genius, and without visiting the hill of Arcetri to salute in silence this ever present memorial of the one of the episodes most unforgetable and most pathetic in the history of sciences. I place before the eyes of our readers a souvenir of last year; the house of Galileo, viewed from the garden, a photograph taken informally and under very poor perspective conditions.

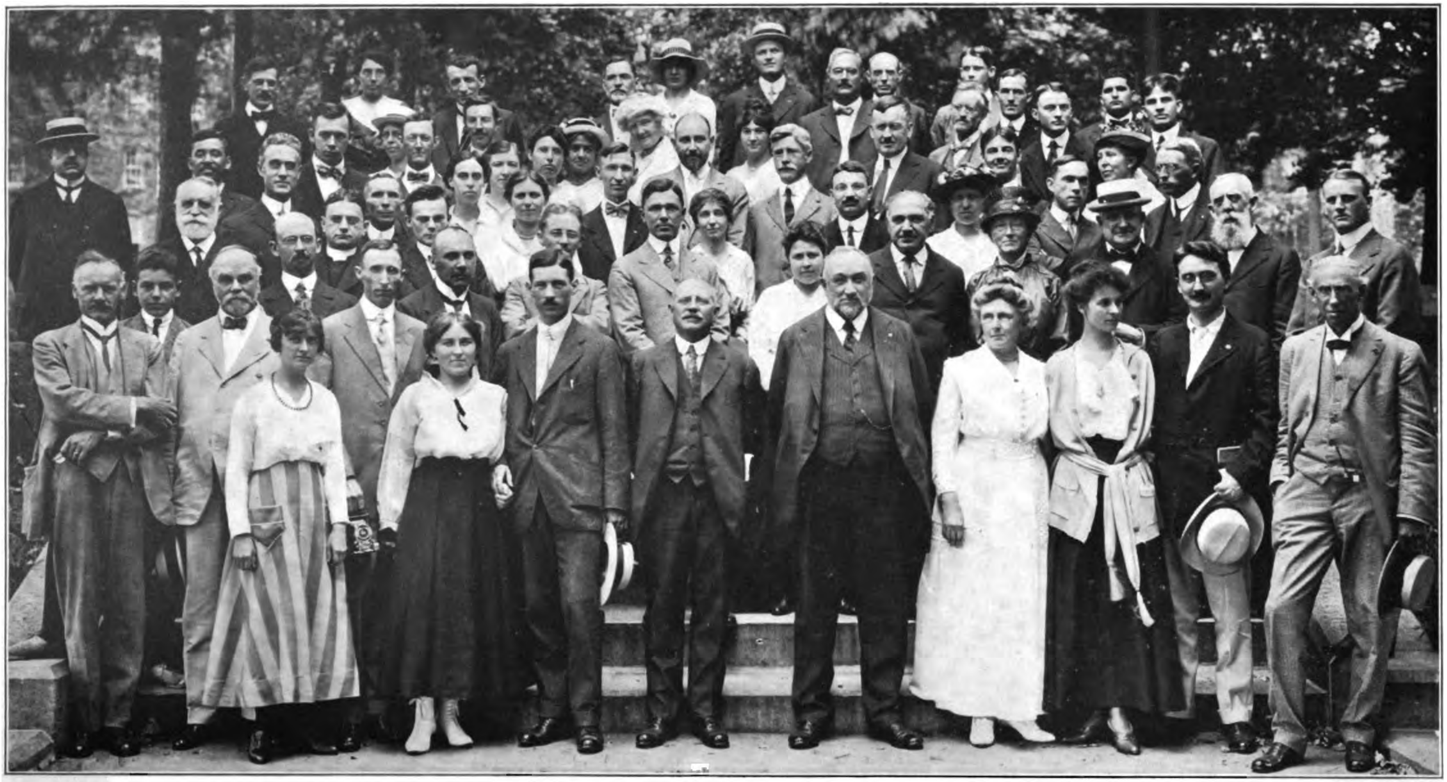
Since the epoch of Galileo, since two centuries and a half, what scientific *rénovation*, what flights in astronomical conquest. Everything has been transformed, transfigured, from the Earth to the stars!"

CAMILLE FLAMMARION.

Encke's Comet Rediscovered.—A cablegram from Copenhagen to Harvard College Observatory announces that Encke's comet was observed Sept. 22.3796 Greenwich mean time in right ascension $22^h 28^m 39^s.0$, declination south $70^\circ 08' 05''$. The position given is an impossible one for Encke's periodic comet which is near aphelion now and must be near the ecliptic. Possibly the declination is south $7^\circ 08' 05''$.

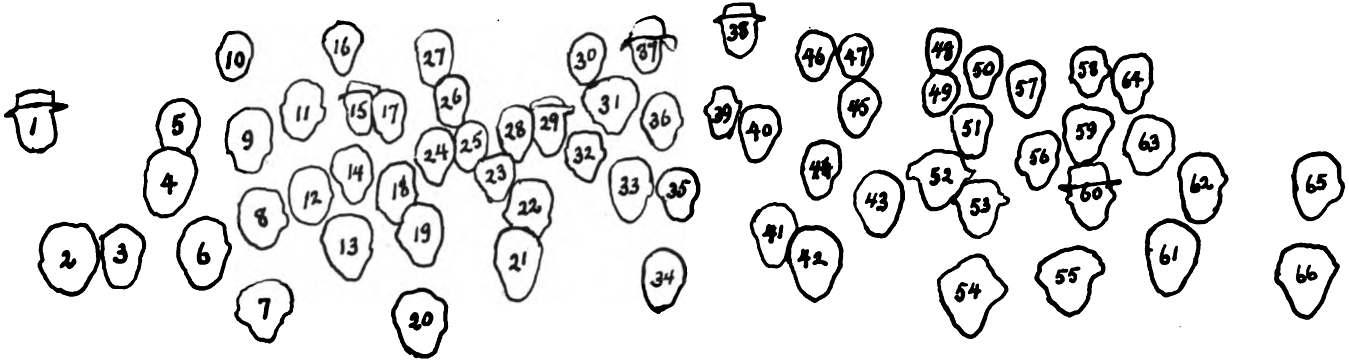
Finding a Suitable Site for the 72-inch Reflector.—In the *Publications of the Dominion Observatory, Ottawa*, Vol. II, No. 11, Mr. W. E. Harper gives a very interesting account of the tests which were made by him of various locations in Canada, in order to determine the most favorable location for the new 72-inch reflecting telescope which is being built for the Dominion Observatory. An examination of available meteorological records and the conditions of accessibility limited the number of locations to be examined to four outside of Ottawa. These were Medicine Hat in the prarie section of Canada, Banff in the Rocky Mountain section, Penticton in the dry belt of British Columbia and Victoria in the Pacific coast region. Mr. Harper spent about two weeks at each place on both the going and return trip. except that Banff was omitted on the return the seeing having proved too bad to warrant a second examination. The principal instrument used was a 4½-inch Cooke photo-visual telescope. Although the elevation of the station at Victoria was only 230 feet, it clearly outranked the stations of greater elevation both in the smallness and the steadiness of the star images, as well as in the small daily and annual range of temperature. The number of clear nights at Victoria and Ottawa is about the same, the latter having any advantage there is. The transparency of the sky was greater at the more elevated stations, but this was offset by the greater unsteadiness of the star images.

PLATE XXXV



MEMBERS AND VISITORS AT THE SWARTHMORE MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY,
AUGUST 30 TO SEPTEMBER 2, 1916.

KEY TO PLATE XXXV



1—John Tatlock
2—E. W Brown
3—Wagner Schlesinger
4—M. B. Snyder
5—K. Hirayama
6—W. R. Warner
7—Marie Bender
8—Joel Stebbins
9—A. T. G. Apple
10—John M. Poor
11—Edison Pettit
12—Walter A. Matos
13—A. F. Beal
14—C. A. Chant
15—Mrs. H. T. Stetson
16—Mrs. Frank Schlesinger
17—Frederick Slocum
18—W. T. Herriott
19—J. van der Bilt
20—Mrs. Robert Truempler
21—Robert Truempler
22—H. van Maanen
23—Mrs. C. J. Hudson
24—Louise F. Jenkins
25—Hannah B. Steele
26—H. T. Stetson
27—Eric Doolittle
28—Margaret Harwood
29—Ida Barney
30—W. S. Eichelberger
31—Mrs. Samuel D. Marshall
32—C. J. Hudson
33—S. A. Mitchell
34—John A. Miller
35—Leah B. Allen
36—Willis I. Milham
37—Susan Raymond
38—W. E. Harper
39—Florence J. Stocker
40—W. L. Wright
41—Mrs. A. B. Turner
42—E C. Pickering
43—Frank Schlesinger
44—John H. Pitman
45—A. B. Turner
46—W. A. Cogshall
47—D. T. Wilson
48—Paul W. Merrill
49—F. W. Very
50—C. P. Olivier
51—S. G. Barton
52—Helen M. Swartz
53—Caroline E. Furness
54—Annie J. Cannon
55—Mrs. Stephen D. Thaw
56—R. H. Curtiss
57—Francois Henroteau
58—C. C. Kiess
59—Harriet W. Bigelow
60—A. W. Quimby
61—Stephen D. Thaw
62—C. L. Doolittle
63—H. N. Russell
64—Philip Fox
65—O. M. Leland
66—E. D. Roe

Popular Astronomy.

Vol. XXIV, No. 9. NOVEMBER, 1916. Whole No. 239

THE SEMI-CENTENNIAL OF THE DEARBORN OBSERVATORY.

PHILIP FOX.

[*Continued from page 487.*]

ADDRESS BY PROFESSOR FOREST RAY MOULTON.

THE PROGRESS OF MATHEMATICAL ASTRONOMY.

You can imagine with what satisfaction I come before you here to explain in a few minutes the advances that have been made during the past fifty years in a subject nearly two hundred years old, and which more than a century ago was so advanced that it took a lifetime to master its complexities. However hopeless the task may be which I face, I can at least tell you about some of the things that are involved in these investigations.

Professor Hale has told you how the doctrine of evolution dominates all modern thought. In order that any doctrine shall be sound and applicable throughout the millions and probably hundreds of millions of years of celestial evolution, at least its fundamental laws must be correct. The one central law on which all discussion of celestial evolution is based is the law of gravitation, discovered by Newton over two hundred years ago. It was at once applied to explaining the motions of the Moon and the planets, and the results were satisfactory. The question then arose as to whether the law is exact enough to account for all the motions of these bodies for indefinite intervals of time. This question has been very prominent in the thought of mathematicians for more than a hundred years. In attempting its answer, difficulties were encountered of a character so serious that I cannot tell you about them fully, and I must confess that not all of them have been entirely overcome.

In spite of the difficulties, the law of gravitation, as it was expressed in 1688, by Newton, is correct to a degree of approximation that has not been attained in any other branch of science. The method by means of which its truth has been so exactly established can be illustrated by a simpler problem. One way to measure the force of gravity at the surface of the Earth is to determine the time in which a pendulum of given length, let us say a seconds pendulum, will vibrate, because the time of vibration depends on the force of gravity. We can measure with a certain degree of precision the time of one vibration and find the force of gravity with corresponding accuracy. But suppose the pendulum makes a hundred swings; the error in measuring the whole interval will be no greater than in the case of a single vibration, and hence gravity will be determined one hundred times as accurately. Since in a day there are 86,400 seconds, in a day the accuracy is increased 86,400 fold. In ten days the precision in the determination of gravity is 864,000 times that obtained from a single vibration. It is evident that accuracy is a result of the accumulation of the effects of the quantity which it is desired to measure. Something like this occurs in testing the law of gravitation by the motions of the heavenly bodies. We cannot verify it with any considerable accuracy by observations of one day or one year. But from observations extending over two centuries, we repeat that the law of gravitation is established with a degree of precision which is not approached in the case of any other scientific law.

Now, what has been accomplished in the last fifty years? What unexplained phenomena of fifty years' ago have been shown to be consequences of the law of gravitation? Half a century ago there were only two outstanding questions, one a small peculiarity in the motion of the Moon, which only modern powerful instruments could reveal, and the other an equally slight peculiarity in the motion of Mercury. These irregularities did not seem to follow from the law of gravitation and astronomers were at a loss to account for them. It was not known whether these discrepancies between theory and observation were due to imperfections in the mathematical processes or to an inexactness in the law of gravitation. The foremost mathematicians of the world from the time of Newton to the present have attempted to answer this question. The difficulties it presented were most formidable and the work required was appalling. For example, Delaunay spent twenty years computing the series for representing the motion of the Moon; his finished work, which was published about fifty years ago, was so extensive that several hundred quarto pages were required for the final answer alone. The work of Delaunay closed an epoch, and though monumental, was yet incomplete from a logical point of view.

In 1877, George W. Hill, of Washington, in a brilliant series of papers, inaugurated a new epoch in the Lunar Theory. From Newton to Hill's immediate predecessors there had been much in common in the methods employed. Hill broke loose from the processes which earlier astronomers had used and with rare originality marked out entirely new paths. Before his work on the theory of the motion of the Moon was completed, he was compelled to turn his attention to the theory of the mutual perturbations of Jupiter and Saturn. Fortunately, the young English mathematician, E. W. Brown, appreciated the importance of Hill's methods and carried them out probably about the same as Hill would have done if his attention had not been diverted. The completed Lunar Theory is a monumental piece of work, giving hundreds of agreements between theory and observation, and furnishing no hint that the law of gravitation is not a sufficiently exact expression of the forces between celestial bodies to be used safely for the long intervals of time involved in the problems of evolution in Astronomy. There are, however, very slight peculiarities in the motion of the Moon which do not follow from theory, but these outstanding discrepancies can be explained in a number of possible ways; and, in spite of the perfection of the work of Hill and Brown, there are still points in which its logic is not complete.

Following the work of Hill came that of the great Frenchman, Poincaré, whose brilliant genius has dazzled the whole world. With excessive modesty he confessed that his work on the problem of three bodies owed its inspiration to Hill. Hill was highly original, but Poincaré added to originality and the highest order of genius a perfect command of all the resources of modern mathematics. Unquestionably, his work will stand out for centuries like that of Newton and Laplace. One of the principal problems which he attacked was that of the exactness of the law of gravitation, and whether, under it, the solar system in which we live is stable; that is, whether the Earth will continue indefinitely to revolve around the Sun at approximately its present distance, or whether it will gradually wind in on the Sun and be consumed, or wind out and wander off into the night of space. He did not completely answer this question, but we hope that fifty years from now, at the hundredth anniversary of the Dearborn Observatory, it will have been settled. But we do know now that the Earth will continue to revolve around the Sun at approximately its present distance for immense ages.

One other great discovery whose applications, at least, have been made in the last half century I wish to mention. A little more than half a century ago the great physical principle of the conservation of energy was announced. In the discussion of the evolution of the universe it is as important as that of the law of gravitation. Professor Hale spoke of the possible evolution of a nebula into a star. In its contraction it developed heat energy in conformity with the principle of the conservation of energy. Helmholtz first applied this principle to contracting suns about sixty years ago, and his work was followed by that of Kelvin, Lane, and Ritter. This work shows us that if our own Sun has no other important source of heat, it cannot have supplied the Earth with heat for more than about 20,000,000 years. On the same basis, the Sun will not give the Earth heat more than about 10,000,000 years in the future.

These figures were derived on the basis that the Sun has no other important sources of heat than that produced by its own contraction. But physicists and chemists have recently found that some atoms break up into their constituent parts, and that in the process an enormous amount of energy is liberated. Possibly the sub-atomic energies are important sources for maintaining the heat of the stars. At any rate, most geologists believe, on the basis of geological evidence, that the Earth is many tens of millions of years, if not hundreds of millions, old, and astrophysicists are generally willing to admit that the life of a star is many times 20,000,000 of years. And if this is true, we may reasonably infer that the Earth will exist and be suitable for the abode of life for tens of millions of years in the future.

So we see that mathematical astronomy for the last fifty years has not been devoted to applying the law of gravitation to current celestial phenomena, for that had been done with almost complete success a half century earlier, but to a rigorous testing of the fundamental laws and principles on the basis of which we shall unfold and come to understand the evolution of the universe from infinity to infinity.

ADDRESS BY PROFESSOR GEORGE E. HALE.

SOME REFLECTIONS ON THE PROGRESS OF ASTROPHYSICS.

The great national edition of the works of Galileo, published by the Italian Government under the skilled and devoted editorship of Professor Favaro, contains a page of unique interest in the archives of astronomy. Reproduced in facsimile from Galileo's note-book, the hasty sketches and rapid notes made during his first telescopic observations of Jupiter lie before us. Copernicus had already published his great work on the revolutions of the heavenly bodies, and Galileo, with a mind singularly free from the medieval prejudices of the day, had accepted the heliocentric view, and had become its chief exponent. But the true conception of Jupiter's system of satellites dawned slowly, and in the few notes made from night to night we can trace its development in Galileo's mind. First regarded as stars, whose changing configurations must result from the motion of Jupiter, the satellites were gradually perceived to belong to a wonderful system revolving about Jupiter as the planets revolve about the Sun. This splendid illustration of the views of Copernicus marked the downfall of the Ptolemaic system and the beginning of modern astronomy.

Of this new era, which arose from the invention of the telescope, it is not within my province to speak. But we must realize how the astrophysics of the last half century is deeply rooted in a more remote past. When Galileo discovered spots on the Sun he opened to investigation the problems of solar physics. In the same century Newton decomposed sunlight into its primary colors, though he failed to detect the dark lines of the solar spectrum. These were first seen by Wollaston and accurately mapped by Fraunhofer in the year of Waterloo. But although Fraunhofer discovered similar lines in the spectra of certain stars, and even detected the coincidence of the double yellow line of sodium in a flame with the double dark line which he called D in the solar spectrum, the significance of these observations was not perceived until 1859.

It is a remarkable fact that firm foundations for the study of both organic and inorganic evolution were laid in this same year. *The Origin of Species*, presenting a vast mass of evidence in support of the theory that new species originate by natural selection, raised the biological world out of the systematism of Linnaeus into the stimulating atmosphere of the Darwinian period. At the same moment the study of the evolution of the Sun and stars was made possible by Kirchoff's law of selective absorption and his identification of the dark lines of the solar spectrum with the lines of the chemical elements in the flame and spark. It became as easy to determine the chemical composition of the solar atmosphere as to analyse a common substance by the ordinary processes of the chemist. Sodium, iron, calcium, hydrogen, in fact nearly all terrestrial elements, were found in the Sun and soon afterward in stars. If a new star blazed out in the Milky Way, its chemical constituents were seen to be of the very kind most familiar to us on the Earth. Thus a marvelous unity, embracing the most remote objects of the universe, was at length perceived. And the instrument that revealed it furnished also the means of tracing the life histories of the stars.

Secchi, Rutherfurd, Huggins, and Draper were the pioneers in this new field. The diverse spectra of the stars were at once recognized as indications of physical development. Huggins' discovery of the gaseous nature of certain nebulae was taken to point to a source of material from which stars might be formed. And thus was set on foot that splendid campaign, rendered possible by the effective use of the objective prism and the modern slit spectrograph, powerfully supplemented by the photographic plate, which has carried us well on the way toward a perception of the course of stellar evolution.

I cannot attempt to trace the tactics, or even the broader elements of strategy, in this great attack on the celestial hosts. Nor may I pause to show how one unit in the stellar ranks, placed as an outpost at the center of the solar system, has been subjected to the varied assault to which his proximity exposes him. The time at my command may be better devoted to a brief survey of some of the larger results achieved and a glance at the means which have made them possible.

So few are the principal types into which the stars may be resolved that Fraunhofer himself detected most of them. Disregarding certain special groups, and confining our attention to the more pronounced marks of distinction, we find that more than a hundred thousand spectra photographed at Harvard belong to the following classes; white stars, in which the lines of helium are conspicuous; stars, also white, in which hydrogen plays the leading role, while traces of the metals begin to appear; yellowish stars, like the Sun, in which the hydrogen lines, less conspicuous than before, are accompanied by thousands of lines due to metallic vapors; and orange or red stars, in which the still fainter hydrogen and stronger metallic lines are accompanied by bands characteristic of titanium oxide. These classes stand in an unbroken sequence, passing over by slow and barely perceptible changes from one to another, and marking out a line of development in which some single variable must undeniably play the dominant part. The differences in the spectra, indicated by the greater or lesser prominence of one or another element, cannot mean fundamental differences in chemical composition. This might be proved in several ways, but is perhaps most clearly illustrated by the recently discovered fact that certain variable stars, of the Cepheid class, undergo a regular variation in spectral type in the space of a few hours, showing at the same time corresponding fluctuations in brightness and in temperature. Again, we know that the spectrum of a sunspot, a cooler region on the Sun, closely resembles that of a red star, which is essentially a cooler Sun.

Temperature, then, is the main source of the observed differences in stellar spectra. The white helium stars attain temperatures of perhaps 20,000° C, the white hydrogen stars may exceed 10,000°, the yellowish stars like our Sun measure about 6,000°, while the red stars range from 2,000° to 3000°, thus falling within the limits attained by our electric arcs and furnaces. With these and certain laboratory devices we may test this temperature hypothesis, and prove its general validity beyond any reasonable doubt.

Thus in the gradations and sequence of their spectrum lines, in color differences corresponding with the shift of the maximum brightness in the spectrum toward the red with lowering temperature, and in other respects no less remarkable, the stars fall into an ordered series. Only recently has it been shown by Kapteyn, Campbell, and Boss that the speeds with which the stars are moving through space also vary in the same sequence; a condition so unexpected and so fundamental that it taxes existing means of interpretation.

At this point astronomy and astrophysics have joined hands in pushing forward the study of stellar evolution. The stars vary enormously in mass, in density, and in surface brightness, and if we are to discuss intelligently the differences in their spectra we must reduce them as nearly as may be to a common basis. A long step in this direction has been taken by classifying stars, not merely on the indications of their apparent brightness, but in terms of their actual brightness—the brightness they would have if they were all brought to the same distance from the Earth. To do this we must know their exact parallaxes, few of which have been determined until recently with the necessary precision. Fortunately a strong group of astronomers, including the director of the Dearborn Observatory, is coöperating most effectively in the photographic measurement of stellar distances. The number of parallaxes already determined has sufficed to yield some remarkable conclusions, when coupled by Hertzsprung and Russell with the results of spectroscopic and photometric investigations.

The first of these is that the white stars greatly exceed the Sun in actual brightness, while the very faint stars are invariably red. Moreover, there appear to be two great classes of stars: those of extreme brightness, which have been called *giants* and those of lesser brightness called *dwarfs*, of which our Sun is a typical example. In the case of the red stars these classes are sharply separated into two groups, between which there seem to be no stars of intermediate brightness.

We may not pursue in their interesting details the conclusions and speculations to which this new conception of stellar classification has given rise. Some of them require the support of further observations before they can be finally accepted, but recent work strongly confirms the view that a point of inflection is likely to enter the time-honored path of stellar evolution. Lockyer, on other grounds, suggested long ago that the curve of development should have both ascending and descending branches, and advanced spectroscopic evidence in support of his conclusion. But his reasoning and results differ in many respects from Russell's.

According to Russell, the red giant stars of great diameter, low density, and low temperature, represent the early stage of sidereal life. Contraction following radiation of heat would give rise to denser and hotter stars, culminating in the intensely hot white stars of the helium class. Further contraction, attended by a reduction of temperature, would result in the dense dwarf stars, which occupy the declining slope of the curve of stellar development.

Whatever our predilections, we must welcome most cordially the new light which has been thrown on our central problem, even if we cling to the classic idea that the white stars are young while the red stars, irrespective of their absolute brightness, represent the period of decline. This older and more widely accepted view has the advantage of affording an unbroken transition from nebular to stellar spectra, which is lacking if we begin our sequence with Russell's red giants. Yet Adams has recently shown that for spectroscopic reasons the red stars should be divided into two groups and the progress of research may soon be expected to provide a reliable means of distinguishing between the old and new views.

Time fails me to show how the spectroscope has extended Bessel's "astronomy of the invisible" into a larger realm, and revealed a new department of double star astronomy, now connected without essential discontinuity with the classic field to which the Dearborn telescope, in the hands of Burnham, Hough, and Fox, has made so many contributions. Nor may I enter the great domain of star-streaming, which belongs primarily to astronomy, though the last wide extension of its boundaries has come from the work of the spectroscope. The old barriers between the physical and the structural problems have broken down, and the old and new astronomy are working together in the closest harmony. Adams has just demonstrated, for example, a simple means of determining a star's distance from a knowledge of its apparent brightness and the ratios of the intensities of certain lines in its spectrum. Founded upon the indispensable parallax measures, which will ultimately extend both its range and its precision, the new method should prove a powerful ally in the further study of both the structure and the evolution of stellar systems.

Turning now to the instrumental side, we observe great changes in the observatory equipment during the last half-century. Telescopes have grown in size and in perfection, while their indispensable auxiliary, the photographic plate, has increased their efficiency a hundred-fold. The spectroscope, no longer the simple aid of the chemical laboratory, has taken its rightful place beside the telescope as an instrument of the most diversified possibilities and of the widest usefulness. No longer limited to the determination of chemical composition of flames and suns, it tells us in no uncertain tones of the motions, temperatures, pressures, magnetic properties, life history, and even the distances of the heavenly bodies. As a result of its growth and refinement the qualitative period of spectroscopy, once a reproach, has given place to an era of measurements which cannot be surpassed for precision in the entire range of science. Brought into closer contact with the physicist and chemist, the astrophysicist has profited without limit by their marvelous progress, and adapted their devices to his special needs. Thus the observatory has received from the laboratory scores of auxiliaries and methods, which have led its investigations into unimagined fields. The bolometer and radiometer, the perfected thermopile and the radiomicrometer, have given us precise measure of the solar radiation and detected its fluctuations, determined the heat of stars beyond the vision of the naked eye, and mapped the vast region of the infra-red spectrum where neither eye nor sensitive plate is of any avail. Selenium and photo-electric cells have proved stars to be variable which were formerly supposed to shine with unchanging light. The recognition of the electron and the rise of modern physics have been reflected in the work of the observatory. The phenomenon of Zeeman, showing the remarkable resolution of spectrum lines under the influence of a magnetic field, is now known to have been seen—though not interpreted—by the solar physicist long before it was detected in the laboratory. The relationship of hydrogen and helium, the effect of an electric field on radiation, and even the principle of relativity are applied or tested in the observatory while yet a novelty in the laboratory or the study of the mathematician. Thus by the use of many new agencies, the astrophysics of yesterday has become the new and broader subject of to-day.

But it is neither in multiplied resources nor in the construction of larger telescopes that we perceive the most significant advance of the half-century. The greatest difference between the present and the past lies in the broadened outlook of the investigator. No longer groping in the dark, or confining his attention to some minute specialty pursued without reference to a larger view, he has widened his horizon and entered into harmonious coöperation with others in his field. Thus the capacity of any single instrument has been multiplied twice, first by the use of the photographic plate or other auxiliary method, and again by the coördination of effort which does away with useless duplication. I have heard the great geologist Suess, a man of the widest interests and richest imagination, describe a certain astronomer as "one of those who busy themselves with those *vermin* of the skies—minor planets and comets." He did not mean that asteroids and comets, which have played such an important part in the larger problems of our solar system, are not worthy of study. What he objected to was the haphazard way in which they are sometimes observed. It is worth while to record, even without purpose, without reason, and without hope, the position of a chance asteroid or a passing comet. But it is far better to mix intelligence with industry, to plan observations in harmony with some central idea, to coöperate with others in pursuit of some large end. Thus each record may be greatly enhanced in value, and given a better chance of holding a permanent place in the archives of research.

Such is the change which has come over the spirit of the observatory. The accumulation of data is no longer pursued blindly, but is based upon an intelligent plan. Such vast problems as the structure of the universe or the evolution of the stars are now attacked in so sane a manner that progress has multiplied by leaps and bounds. And this is because of a freer and better use of the scientific imagination, acting under the inspiration which we owe in no small measure to Lyell and to Darwin and to others of their time. The theory of evolution is no longer bounded by the limits of the nebular hypothesis or the principle of natural selection. Rising out of these great conceptions, it has expanded into a vast and sweeping vision which embraces all nature. From the whirling electrons in the minute solar system of the atom to the globular star clusters, the spiral nebulae, and the great star streams of the sidereal world is now but a step. Without break of continuity, we study the nature of the electron and the composition of nebulae, the constitution of the atom and the formation of the stars, the organization of complex matter and the evolution of the Earth. We watch with Lyell and Suess, and others of our own day, the development of the Earth's face and the ebb and flow of molten and of aqueous tides. Deep below the Cambrian rocks, embedded in those great sedimentary deposits which filtered during slow millions of years through the depths of prehistoric seas, we find the first signs of life. We isolate the unit of the biologist, and as we marvel at the complexity of the cell as contrasted with the electron, we admire the patience and perseverance which has brought order out of chaos in the intricate mazes of organic existence. We watch the rise of strange life forms, their transformations and effacements, the long intervals of stagnation and repose, the renewed appearance of life in other aspects, graceful and grotesque, gigantic and inconceivably minute. Surveying with Darwin the wide extent of the dead and living world, we perceive the play of a single principle in thousands of diverse organic forms, and see it restore the continuity of that evolutional progress which is more easily traced among the simpler elements of inorganic nature. We observe the modern biologist, applying the experimental method and producing in his laboratory the variations and mutations which have occurred so often in the history of terrestrial life. We follow the prolific researches of the anthropologist, see him restore the missing links, and trace the marvelous advance which has developed man out of the low intelligence of the anthropoid world. Finally, we see the crude efforts of the first artist endeavoring to express his conceptions, the gathering together of peoples, and the rise of the earliest civilizations. And as we survey the long process of evolution, in its unbroken manifestation from electron to star, from Earth to man, we feel the impulse which has taught us no longer to be content with the limited view point of the specialist, but in whatever we do, howsoever restricted our field, to look out toward the widest expanses of nature and profit in our researches by the clarifying and inspiring example which has been set for us by the leaders of modern thought. Let me close with the words of the great geologist Suess* one of these leaders now unhappily lost to us:

"What a memorable half century we have lived through! During this time, under the influence of increasing knowledge of nature, all human conceptions of the Earth have changed. It is remarkable, however, to see how often the single inquirer, bent upon the object of his quest, fails to comprehend the broader aspects of a problem by whose details he is fettered, just as the stone-cutter clinging to a facade, cannot see the splendor of the structure on which he himself is engaged. And yet there is a special charm in geological studies precisely on account of the extraordinary range of accommodation that is demanded of the eye, of the same eye which now examines the disintegration of quartz in a thin slide under the microscope, now sweeps over snowy mountain peaks, over dark precipitous cliffs and verdant vales, and with commanding glance reads their structure in the features of the landscape. But not less is the demand on the adjusting powers of the mind. From the most subtle conclusions derived from an ingenious experiment the geologist must be able to lift the mental eye over hill and valley into the most distant parts of the universe. There the glowing spectra of nebulæ teach him that even now the great processes of world making are not yet ended. With the aid of instruments he can daily witness the greatest eruptions of superheated gases emanating from the body of our Sun. Photography spreads before him the pictures of the desolate crater-fields of the Moon.

"Returning to his Earth he now perceives that the sum total of life's phenomena not only forms a single phenomenon, but that it is also limited by space and time. It occurs to him now that the stone which his hammer strikes is but the nearest lying piece of the planet, that the history of this stone is a fragment of the history of the planet, and that the history of the planet itself is only a very small part of the history of the great wonderful and ever changing Cosmos.

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* Spoken at the closing banquet of the Ninth International Geological Congress, Vienna, August 27, 1903. See Schuchert, American Geologist, Vol. 33, January 1904.

"His heart then thrills; he feels called as a co-laborer on the most sublime problems in which feeble, mortal beings can take part. Then, too, he sees that the fundamental lines of structure coursing over the Earth's surface have nothing to do with the political lines separating the nations. The vastness of the problem itself makes the concord of civilized nations natural, and they remain separated only through their emulation, all filled with the idea that mankind in general will most highly esteem that nation which is in the position to offer the most and the best of noble example, of new truth and of ideal worth."

To-day, in the midst of the great war, what a melancholy interest attaches to these last lines! Yet they express a lofty ideal, toward which we may hope that the world will continue to grope its way, even though final attainment must lie far in the future.

DARK NEBULAE.

RUSSELL SULLIVAN.

On a fine summer night if one looks at the sky below the bright star Deneb in the constellation Cygnus he will notice a dark spot which interrupts the surrounding brilliance of the Milky Way. This is the northern Coal Sack which the older astronomers regarded as an opening in the Milky Way through which one can look out into the darkness beyond the stars. About the same distance north and east of Deneb is another spot (described by A. and W. Maunder as about the diameter of the full moon) much darker than the surrounding sky. A dark, narrow lane issues from it and runs across the Milky Way, suggesting a flask with a long neck.

In the southern hemisphere a still more conspicuous patch of darkness is surrounded on all sides by the Milky Way, which in these latitudes is exceptionally bright and suggests the approach of dawn when on the horizon. It is about half as large as the bowl of the Big Dipper and never escapes the notice of the most casual observer. Early explorers called it the Coal Sack. It is treated in the folk-lore of Australia and Peru. In the early part of the seventeenth century

Josephus Acosta said that he had seen spots in the sky in Peru. "These spots," he wrote, "are in colour and form like unto the Eclips of the Moone, and are like unto it in blackness and darkness."

According to Allen, the tribes of the Amazon know a dark spot near Orion and call it the "Peixie Boi." There is a dark spot in the great nebula of Orion often called the Fish Mouth. It is darker than the surrounding sky and partly covered by luminous matter. Close by the nebula is a dark, bean-shaped object partly obscuring the nebulous matter near it. It appears to advantage on the Yerkes and Lowell photographs. There are other dark objects in Ophiuchus and Scorpio which are also visible to the naked eye.

The Herschels both noticed dark spots in the sky, but it has remained for Wolf, and especially Barnard, to photograph them. Doubtless some of these spots can be explained as patches of sky devoid of stars, but in view of the evidence it is more likely that the majority are true areas of dark nebulosity. Barnard's photographs taken with a portrait lens and wide field of view, show dark vacancies winding in and out among the stars and nebulae of the Milky Way, some of which can even be followed as faint projections on the surrounding darkness. Faint stars often appear in the vacancies, but these are most likely between us and the dark regions. Hinks says that when the dark body is due to gas, only the luminous nebulosity is darkened; when it is due to dust clouds, both lucid nebulae and stars are blotted out, and if we apply this criterion we must assume that these stars are shining through masses of gas. Slipher has spectrographically traced dark, stationary calcium clouds in front of some of the stars in Scorpio, and recent investigations by Daniel show them to exist between us and certain stars in Orion. Many curious figures and letters are traced in the bright back-ground by the smaller and less diffused spots, and numerous dark places are edged with a faint glow, often merging insensibly into adjacent bright nebulae. Sometimes the dark nebulae themselves have a leaden or tinted aspect, as Barnard's visual observations have shown. There are even comparative degrees of darkness, or "gradations of obscurity," as Miss Clerke puts it; some spots are darker than others and remind one of the umbrae and penumbrae of sun-spots, as Barnard has remarked. Thus the less dark spots must "shine" with a very faint glow. There are many gradations of luminosity among the vast, irregular nebulae in the Milky Way. In Sagittarius Barnard describes a small black hole in the Milky Way, like a black planetary nebula, round and sharply defined and not due to the presence or absence of stars. In the photographs of the Taurus region the dark lanes brighten and darken again—stars are absent from them and they seem to be independent of the stars. In the photographs of the region around Rho Ophiuchi the nebulous material is actually condensing around the stars, and the dark lanes are in intimate association with both nebulae and stars. Near this star there is a great dark lane running east and west and Barnard mentions a case where the telescope in observing transits of stars had been unintentionally placed on this rift, with the result that no stars appeared—the rift was slowly drifting from east to west through the field of the telescope. This rift suggests the great cleft which divides the Milky Way into two streams and extends from Cygnus in the northern to Centaurus in the southern hemisphere. Perhaps it would strain the facts to assume that this long bifurcation is caused by a dark mass absorbing the galactic light behind it. Turner in counting the stars of various magnitudes in the great Astrographic Catalogue, has found evidence of two large tracts of nebulosity where there are not enough faint stars in comparison with the bright ones. He suggests that a great cosmic cloud veils the light of the more distant stars.

As some of these objects are projected against space itself, without a background of stars or nebulae, Barnard thinks that space is faintly luminous, enough to show a dark object in relief. See also says that the background of the night sky is faintly luminous. Barnard makes an interesting comparison between photographs of the net-work nebula in Cygnus and its analogue, a dark object in Cepheus. They are similar in shape, but one is bright and the other dark. He suggests that nebulae die out just as stars do. Hind's variable nebula in Taurus is an example of a nebula formerly bright in small telescopes, but now so faint that powerful glasses only show it with difficulty. As these dark objects are opaque enough to absorb the light of the stars lying beyond them, Barnard thinks that they are relatively dense and more massive than ordinary nebulae. Thus they must exert a considerable influence on the movements of the stars taken as a whole. Eddington says that there is even some of this absorbing nebulosity within the limits of the central aggregation of stars of which the sun is a member, although most of it is involved with the star-clouds of the Milky Way.

Some years ago Holden, in comparing Sir John Herschel's observations of the Trifid nebula in Sagittarius with recent observations, noticed that a star formerly in the middle of a dark lane and presumably in front of it, was on the bright edge of the nebula. As the star had not moved with reference to neighboring stars, it would seem that the bright and dark parts of the nebula had drifted away from the star. Campbell has recently measured the radial velocities of a number of irregular gaseous nebulae by the spectrograph, and finds that they have small average motions. The extended gaseous nebulae congregate in or near the plane of the Milky Way and as the dark nebulae often appear to be stagnant extensions or margins of their bright companions, we may infer that they too are mostly gaseous and possessed of small radial velocities. Campbell has also shown that hydrogen is glowing on the confines of the Orion and Trifid nebulae, while he finds nebulium in the centers of these nebulous masses. These observations imply that the darker clouds are principally composed of hydrogen. (The same is true of certain planetary nebulae and the ring nebula in Lyra, according to the investigations of Wolf and Burns, and Wright). It is possible that some of these dark objects may shine by reflected light. Such is the case with the nebula surrounding the star Merope in the Pleiades, as Slipher has shown by the spectrograph. The new star in Perseus which blazed forth in 1901, illuminated a nebula which previously was not known. Novae (or new stars) always appear in or near the plane of the Milky Way, where the chances of a collision with dark or lucid nebulae are much increased.

Eddington, Slipher and others have recently presented strong evidence that the spiral nebulae are external Milky Ways. The absence of measurable parallax and proper motion, combined with Slipher's discovery of great radial velocities, strengthens the probability that they are outlying universes. Slipher finds that the spirals give a spectrum similar to that of the sun and rather advanced in spectral type, and Fath has shown that the integrated spectrum of the Milky Way is solar in type. Similarity of spectral type implies that the spiral nebulae and the Milky Way belong to the same class of objects. Photographs of spiral nebulae which happen to lie edge-wise to our line of sight show a long dark rift dividing the nebula equatorially. The Milky Way if viewed edge-wise would present a similar line of light divided length-wise by dark absorbing nebulosity. As the sun is almost in the plane of the Milky Way, we look towards the dark nebulae and are prevented from seeing objects lying beyond them. Thus the external spiral nebulae are for the most part invisible in and near the plane of the Milky Way, but appear in great numbers the farther we look away from it.

Where do the dark nebulae belong in the scale of cosmic evolution? In view of their intimate association with the extended, gaseous nebulae of the Milky Way, it is probable that they precede the latter and thus are at the very beginning of cosmic evolution.

THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

[*Concluded from page 499.*]

SCHEINER AS A PLAGIARIST?

To return to the accusation of plagiarism which has been made against Scheiner. There have come down to us, in the correspondence between Galileo and his friends, statements which show that the learned Italian believed that Scheiner had at an early date received news of the discovery of the spots and had acted on this to his disadvantage. The chief evidence for this is contained in a long letter from Galileo to Alfonso Antonini, dated 20th February 1638. The letter was written some years after Galileo's condemnation by the Papal Tribunal, and was principally concerned with the librations of the moon. Galileo writes:*

> It grieves me that I cannot give you complete satisfaction, and especially because of your having requested it of me with so much affection, and at the same time have shown yourself very jealous that another one having been able to learn of this novelty which was discovered by me, should wish to make himself the first observer of it, as has happened with other admirable observations of mine, and in particular with the solar spots, where Christoforo Scheiner with such boastful audacity, not only boasted for himself priority in time of discovery, but conjecturing more judiciously than I, was able to discourse on the nature and behaviour of these spots, expecting nothing less from the ignorance of his reader than from his own arrogance. And, as if he had not already published in printing his three letters so full of ignorance and all the errors that can be conceived of, and on the other hand having seen similar letters of mine written about the same observations, but full of conjectures, all of which have since been verified, he, attributing to himself all the truths which he has learned from me, makes himself in the Rosa Orsina, or Orsa Rosina as indeed he gracefully changes it, the author of all truths and defames me as a most ignorant man. For clear evidence of his vanities and of my correct reasoning it is sufficient to read the above mentioned letters by me and by him, which are printed together in one volume. As to his having seen these spots a long time after me, in addition to other testimonies; there are two from two Fathers of the same order. One of these is Father Adam Tanner; in his *Astrologia Sacra*,† on page 49 I read these words, "Assuredly the great astronomer Galileo, the first discoverer of these wonders of the skies, maintains that these spots which overshadow the sun are, etc." And your Grace should know that his Father lived in Ingolstadt, and lectured at the same college with Father Scheiner, and indeed at

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* *Gal. Op.* 17, 296.

† *Astrologia Sacra, hoc est orationes quinque, quibus explicatur an et qua ratione fas sit homini Christiano de rebus occultis, praesrtim futuris, ex astris iudicum ferre, ecc.* Ingolstadtii, 1615.

> the same time that the latter was making observations of these spots; and as you see he calls me the first discoverer, nor does he mention Scheiner in his whole book. As for the other Father, I prefer not to mention his name at present, but he is still living and he affirms that he was the first who gave information to this Father Scheiner regarding the spots exhibited by me during the time that I was in Rome, where on various occasions I showed them to many great prelates in the Quirinal Gardens, which happened many months before Scheiner mentioned it in his letters to Marco Velsero, Duumvir of Augusta. But why does this lunatic desire to make himself precede me in the time of his discovery, and these observations regarding which he discourses so foolishly, while I lacking observations announce so many conjectures, since confirmed as undoubted truths?

The identity of the Father to whom Galileo refers, and whom he 'prefers not to mention' is made clear by two letters from Giovani Pieroni, Imperial Engineer, and a former pupil of Galileo. The first of these is dated January 4, 1635, from Neustadt near Vienna, Pieroni writes:*

> There is found in these parts Father Sciainer (Scheiner) with his "Rosa," which is likely to rot, because having brought here many copies of that great wretched book he cannot dispose of them, and he is angry thereat. I have seen [a copy of] it, loaned to me by a person who knows and esteems you, and who associated with you in Rome, and who has told me that he remembers as clearly as one can say that he remembers anything that he was the first who told Father Sciainer that spots were seen on the sun which were first discovered by yourself. Hence, I have a living witness that the first book of that volume is false.

Naturally there followed an inquiry from Galileo concerning the identity of the "person" referred to. Pieroni replied, October 10, 1637:†

> Father Guldino has published here his book *De centro gravitatis*, and he has given me a copy to send to you whom he esteems and reveres greatly,......This Father is the one who assures me that he was the first to inform Father Scheiner of the spots on the sun discovered by yourself.

Concerning the probable accuracy of these statements, Favaro shows‡ from the most trustworthy sources that Guldino, who became a Jesuit in 1597, was at Munich until 1609, and afterwards, "since his extraordinary aptitude for science had on various occasions shown itself, he was called to Rome and ordered to devote himself to philosophy and mathematics,"¶ remaining there until 1617 when he went to Vienna. Consequently Guldino must have been in Rome during April 1611, at the time when Galileo was publicly exhibiting the spots. He would have been attracted by such matters, and hence, there can be no doubt of the possibility of his communicating with Scheiner as above indicated. Particularly as Scheiner and Guldino had become acquainted while at Munich, and afterward maintained an active correspondence on scientific matters.

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* *Gal. Op.* **16**, 189.

† *Gal. Op.* **17**, 193.

‡ *Op. cit.* p. 748.

¶ *Bibliotheca Scriptorum Societatis Jesu*, Romae, 1676. p. 647.

From this evidence it seems safe to assume that the statements of Pieroni are substantially correct. Galileo, as we have seen, arrived in Rome on March 29. How soon after his arrival he exhibited the spots in the Quirinal Gardens, we have apparently no means of determining. It seems safe to assert that the spots must have been exhibited before the 24th of the following April, for on that day the commission of the Collegio Romano reported its findings to Cardinal Bellarmine. However, Fahie states:*

> Immediately after the report of the Bellarmine commission, Galileo announced a new discovery in the heavens, namely, dark spots on the body of the sun, which, toward the end of April 1611, he showed to several prelates and savants in Rome.

Fahie does not mention the source of this information, and hence we are uncertain whether it is mere conjecture, or is based on real evidence. In any case Guldino's letter would not have left Rome much before the latter part of April. Since in those days means of communication were slow and uncertain, Scheiner could not have received the letter before the end of May, as is pointed out by von Braunmühl. That this is a reasonable limit, is learned from the fact that Galileo's second letter on the spots to Welser, forwarded on the 23rd of August from Florence, was not received until the 2nd of October.† But in the first letter to Welser, dated November 12th, 1611, Scheiner asserts that his first observations were made seven or eight months previously, that is, one or two months before he could have heard of Galileo's discoveries through Guldino's letter. Hence Pieroni's letters cannot be considered as evidence that Scheiner was a plagiarist.

However the most important point in the discussion is whether or not Scheiner actually saw the spots for the first time in March or April 1611, as he asserts in the letters to Welser and in the *Rosa Ursina.* This is a question which it seems impossible to solve by any direct evidence. But if a condemned man should be pardoned because convicted by circumstantial evidence only, the writer believes that Scheiner should. He states in the *Rosa Ursina* that his first observations were made in the presence of Father Cysat. Cysat died in 1657, or more than twenty five years after the publication of the book, so that one can hardly believe that Scheiner's assertion is a deliberate falsehood. But, if Cysat had agreed to enter a compact with Scheiner to maintain the claims of the latter, it would have been more natural for Scheiner to have placed the time of the first observation at a far earlier date, in order to avoid all possibility of suspicion that he had received news of the discovery made in Italy.

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* *Op. cit.* p. 128.

† *Gal. Op.* **11**, 407.

In the preface to the *Rosa Ursina*, as we have seen, Scheiner asserts his innocence of any previous knowledge of the existence of the spots.

> Father Tanner perceived the same spots,.....on account of some previous rumor, as he says, of which, however, not the faintest whisper reached my ears.

But Scheiner's methods have not established his reputation for veracity on matters of this character. However, Welser comes to his aid, and asserts in the letter of March 16, 1611, to Johann Faber, already quoted, that Scheiner knew nothing of Galileo's discovery:

> Moreover, I can affirm that my friend who calls himself Apelles, knew nothing of the observations of Galileo.

The strength of this testimony cannot be denied, for the honorable Mayor of Augsburg held Galileo in the greatest esteem, and was also a life long friend of Scheiner; although it must be admitted we do not know how he learned all the facts of the case.

With the sincerity of Scheiner's declarations, and the pleasure that he showed because of the agreement between his own observations and those of Galileo, as quoted by Welser in another letter to Faber,[*] Domenico Berti was so impressed, and remarking that he found such a clear imprint of truth, was forced to believe that Scheiner had discovered the sun-spots without any knowledge of the previous observations of Galileo.[†]

On the other hand there is no doubt that Galileo's observations, whether made at Padua or in the Bandini Gardens at Rome, were well known in Germany. The letters of Welser to Paolo Gualdo, to Johann Faber, and to Galileo testify to this. Even Scheiner, in the above quotation, tells us that while he was making his October observations, Father Tanner at the same college was also observing the spots on account of some previous rumor, of which Scheiner says he was ignorant.[‡] But this was in October; how much previous to this the spots were known in Germany is not apparent. Wohlwill, in discussing this question believes[¶] that the "previous rumor" refers to the *Narratio* of Fabricius, which had come to Ingolstadt from Frankfurt. This does not seem probable when we recall how little known was the *Narratio*, and the difficulty that Kepler had in obtaining a copy. Tanner, as we have seen, refers in his *Astrologia Sacra* to Galileo as the first discoverer, and hence it seems more probable that the "previous rumor" was of Galileo's observations and not those of Fabricius.

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[*] *Gal. Op.* **11**, 428.

[†] *Memorie della Reale Accademia dei Lincei, Scienze, Morali, etc.* Serie 3, **10**, 7. Roma, 1882.

[‡] Circumstantial evidence does not support Scheiner in this, however.

[¶] *Arch. Geschichte der Naturwissenschaften und Technik.* **1**, 443. (The author has not had access to this reference.)

From all this, the most reasonable deduction is, that Scheiner did see the spots independently as he asserts, in March or April 1611; but on account of doubts of their reality, strengthened by the admonitions of Busaeus, kept the knowledge of them to himself. On the receipt of Guldino's letter in the summer or early autumn of 1611, he again turned his telescope to the sun, and the doubts as to the reality of the spots having been removed by the knowledge that they were seen elsewhere, became convinced that they were real objects of some sort, and wrote the letters to Welser in order to prevent the discovery being "snatched from his hands" by forestalling Galileo in the announcement. This view is strengthened, when we recall the stress that Scheiner places upon the fact that Galileo had failed to make the proper announcement of his discovery, and that on this account his claims for priority were not worthy of recognition because having no foundation or support.

SUMMARY AND CONCLUSION.

Considerably more might be written about the early observations of the solar spots, but space will not permit. The four men whose observations have been discussed are worthy of particular note, because they must be considered as independent "discoverers." Others whose work was perhaps less important were contemporaries or followed them; such were Simon Mayr, Kepler, Hevelius, Gassendi, etc., but the observations of these were only made after knowledge of the existence of the spots had come to them; consequently their observations have not been considered in the present discussion.

Concerning the inaccurate statements found in the various histories of astronomy concerning the discovery of the spots, all that need be said is that the earlier historians were not in possession of the facts as we know them today. If Grant, Delambre, and others had had access to such works as the *Edizione Nationale* of Galileo's works, it is safe to venture that the erroneous statements for which they are responsible, would not have been written.

Galileo was the first to observe the spots with the telescope. His first observation was made at Padua during the summer of the year 1610. The reasons for asserting this have been related at length; briefly they are, Galileo's own statements as contained in the letter to Guiliano de' Medici and in the *Dialogues*. These statements are confirmed by Micanzio's letter of September 27, 1631, and by Viviani's *History*.

The public exhibition and demonstration of the spots was made in Rome during April or May 1611; the evidence supporting this is contained in the letters from Piero Dini, Angelo de Filiis, Agucchi, and the Jesuit Maelcote.

Galileo's first mention of the spots in a written document, is in the letter of October 1, 1611, addressed to Cigoli. From the wording of this letter it is very evident that Galileo had been aware of the existence of the spots for some time previously. The first printed publication in which he mentioned the spots is the *Discourse on Floating Bodies*, completed in October 1611, and published in May of the following year.

Following Galileo, Thomas Harriot appears to have been the next observer of the spots with the telescope. Harriot's first view of the spots was obtained on the 8th of December 1610; the evidence for this is the original observation itself.

Johann Fabricius' first observation, as related by his father David, in the *Prognosticon Astrologicum* for 1615, was made on the 27th of February 1611. Fabricius was the author of the first printed work in Europe containing an account of the spots; this bore the date of dedication June 13, 1611, and appeared from the printer in the fall of that year.

The first observations of Christopher Scheiner, as related in the letter to Welser and in the *Rosa Ursina*, were made during March or April 1611. There is no evidence to support these assertions other than Scheiner's own statements; but from the circumstances it seems reasonable to accept these as an account of the actual facts. The first letter to Welser was dated November 12, 1611, the earliest recorded observation October 21, 1611.

The observations of Fabricius and Harriot were, from the scientific standpoint, of small value. However, Fabricius' *Narratio* contains the first statement of the probable solar nature of the spots and of the rotation of the sun. Fabricius perceived that the changes in the motions of the spots across the disk might be the result of foreshortening, the spot being situated on the surface of the rotating sun. But, from fear of adverse criticism, Fabricius expressed himself very timidly.

To Galileo really belongs the credit for first asserting that the spots were a part of the sun, and, once convinced of this, he unhesitatingly supported his assertions with conclusive proofs and arguments. The first announcements of the sun's rotation, of the faculae, of the granulation, and of the spot zones were made by Galileo.

Scheiner's earlier observations were of small scientific value, owing chiefly to his belief in the "spotless sun" of the Peripatetics; but this is by no means true of his later observations. These observations, when one considers the crude instruments at Scheiner's disposal, were extraordinarily accurate, as was the determination of the elements of the sun's rotation; and for these he deserves the highest praise. The great *Rosa Ursina*, longwinded or "inflated with conceit" as certain parts of it may be, stands as a splendid monument to Scheiner's perseverance and skill; and one can only regret that the contents of this remarkable book have been so generally unknown.

Numerous attempts have been made by the supporters and friends of Scheiner to discredit Galileo, and to proclaim the Jesuit as the discoverer of the solar spots. These attempts can be traced directly back to Scheiner's time, and have been made largely by those whose religious views have affiliated them with him. Their efforts have been particularly unfortunate, in that they have reacted to produce the opposite effect from that intended; for they have tended to prejudice opinion against Scheiner, rather than in his favor, and have brought the relatively unimportant question of discovery into prominence, while the more important facts and results deduced by the early observers have been generally overlooked. This policy on the part of Scheiner's over zealous supporters will probably explain why so little is known today of the contents of the *Rosa Ursina* or of the *Istoria e Dimonstrazioni*; few historians of astronomy mention even the existence of the latter, much less its contents, while the *Rosa*, because of Delambre's unfortunate and unjust criticism, is generally regarded as a subject only for jokes. In truth one must admit, as Micanzio states, the mere size of the book would tend to discourage readers; but if so much energy had not been wasted in the controversy over the discovery, more would be known today of Scheiner's observations.

Concerning the attempts to discredit Galileo, a few words may not be out of place. The chief argument has always been that the assertions of Galileo in claiming the discovery were not to be relied on because there were no records of actual observations to support them; while the statements of Micanzio and Viviani were either ignored, or their truth denied. Also, that inasmuch as Scheiner's first letter to Welser preceded Galileo's by some six months, Scheiner must certainly have been the first to see the spots. But the public demonstration at Rome, concerning which there can be no doubt, for even the Jesuit Maelcote testified to it, and he was distinctly not a partisan of Galileo, preceded Scheiner's first authentic observations of October 21, by half a year. Even disregarding this, Galileo's letter to Cigoli, dated October 1, 1611 preceded Scheiner's observation by several weeks. Consequently there can be no real reason for maintaining that Scheiner saw the spots before Galileo.

The weak side of the argument, which clearly shows the personal bias of Scheiner's supporters, is that Galileo's statements, confirmed as they are, have not been regarded as truths, while Scheiner's assertions of his observations of the spots in March or April 1611 have always been accepted without question, notwithstanding that these assertions are absolutely unconfirmed by any evidence whatever. Even Cysat, who appears to have been present at the time, preferred to remain silent, even during the quarrel which followed, for there is no statement from him affirming or denying the truth of Scheiner's assertion; at least no evidence of any such statement has come down to us.

Thus we have traced the history of the discovery of the solar spots from the time of the first observations by Galileo to the publication of the *Rosa Ursina* twenty years later. It is doubtful if at any period of the development of solar astronomy have such vast strides forward been made in so short a period of time. During these twenty years were discovered all the important phenomena ordinarily visible on the sun's surface as we know them today, with one exception—the periodicity of the spots, which was not announced until 1843. The two hundred years following the publication of the *Rosa Ursina*, although most fruitful in planetary discoveries and in the development of mathematical astronomy, were practically blank as far as solar discoveries were concerned. This seems rather remarkable when we recall that such men as Huyghens, the Cassini's, Roemer, Flamsteed, Halley, Bradley, etc., were actively engaged in observational astronomy during this period. Possibly it was as Weidler suggests, that Scheiner "had conquered himself, the sun, and posterity in despair of any better observations," so that nothing remained to be discovered unless with the aid of new instruments of research.

With the attempts by Galileo, Scheiner, and the early observers to explain the perplexing phenomena observed on the face of the sun with the assistance of the laws of physics and chemistry as they were known at that time, was born the new science of Astrophysics. This science is not concerned with the positions or movements of the heavenly bodies, but instead considers the equally important questions of their constitution, and the physical and chemical conditions that prevail upon them.

Two hundred years later, studies of the sun's light brought about the first great advances in the new science of Astrophysics. Through the investigations of Wollaston, Fraunhofer, and Brewster, which finally culminated forty years later in the epoch making researches in spectrum analysis by Kirchoff* and Bunsen, are we now able to recognize the chemical elements present in the sun and other celestial bodies, and to gain some knowledge of the physical conditions on these bodies under which the elements make themselves manifest.

Looking toward the future, it seems that the greatest advances in Astrophysics must come through the study of solar phenomena. In the sun we have a typical star, placed close at hand, and with the insight and knowledge gained by the study of its phenomena, coupled with intelligent and well directed laboratory research, we may be able to solve the extraordinarily perplexing problems presented by our more distant stellar neighbors.

As with the first studies of the sun was born the new science of Astrophysics; to be nourished to sturdy youth, after a long and uneventful childhood, by the investigations of the sun's light in the early part of the last century; so at the present day, the knowledge that will later bring about the growth and development to maturity of this new science must be looked for from the same source. Then, as we consider the phenomena of the stars, and the multitude of problems that are there presented to us for solution, let us hold ever before us the words of Scheiner:

> These and other questions of celestial physics arouse us to the opportunity offered by these phenomena. He, who wishes to solve them truly and correctly without deceit or falsity, will resort to the sun, and from this will elicit better answers that from the Delphic Tripod and Apollo himself.

Philadelphia, Pa.
January 1915.

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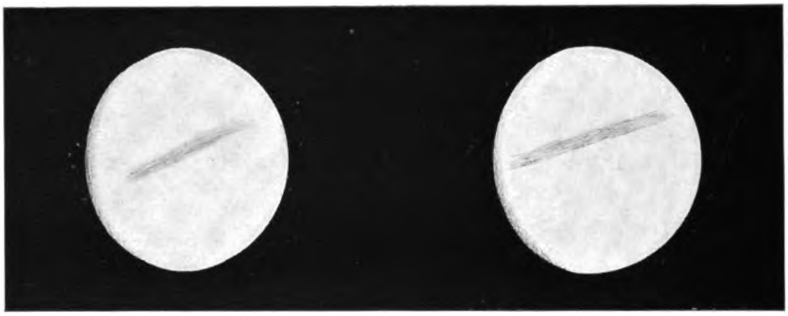
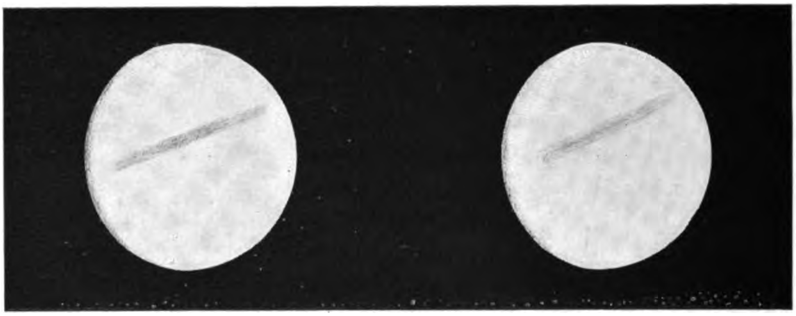
* It may be remarked that although almost universally credited with the discovery of spectrum analysis, Kirchoff was not the first to discover the all important relation between spectrum and element, nor was he even the first to announce the discovery of this relation. It has recently come to light, through the researches of Dr. W. J. Holland (*Annals of Carnegie Museum of Pittsburg* **8**, 215, 1912) that this honor rightly belongs to Dr. David Alter of Freeport, Pennsylvania, who published in 1854 and 1855 in Silliman's *American Journal of Science* (Second series, **18**, 55: **19** 213) the announcement of this discovery, mentioning the applicability of the method of spectrum analysis to the study of celestial phenomena.

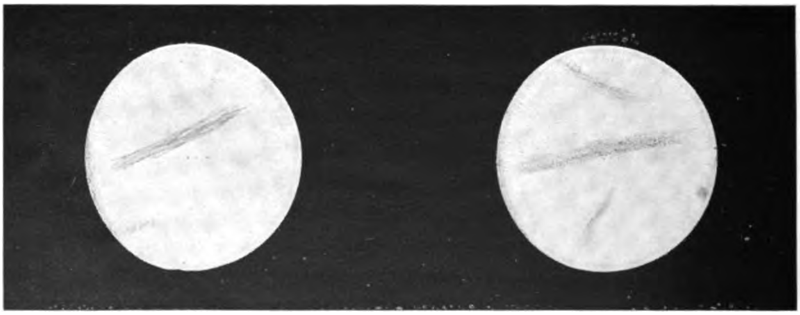
PLATE XXXVII



June 9 2^{h} 15^{m} Gr. M. T. June 21 0^{h} 10^{m} Gr. M. T.



June 23 0^{h} 45^{m} Gr. M. T. June 23 23^{h} 50^{m} Gr. M. T.



July 7 3^{h} 15^{m} Gr. M. T. July 19 0^{h} 45^{m}—5^{h} 30^{m} Gr. M. T.

DRAWINGS OF VENUS IN 1915 ILLUSTRATING THE ELIMINATION OF THE PERSONAL EQUATION.

POPULAR ASTRONOMY, NO. 239

A BRIEF NOTE ON A NEW DETERMINATION OF THE NATURE OF THE ROTATION OF VENUS.

DAVID H. WILSON.

With the view of learning something about the rotation of Venus, I observed her during every hour of steady air from December 15, 1914, to March 10, 1915, and from June 5, 1915, to September 1, 1915. Half of the time I used the 20.4-centimeter Brashear refractor of the Philadelphia Observatory; the rest of the time I used any one of three other instruments, all located on the site of the Flower Observatory of the University of Pennsylvania. Though the latter site is in the eastern part of the United States, the local topography assures the equality of the definition at noon to that at night. As Venus was never far from the sixth hour of right ascension when I made my best observations, the steadiness of the air usually remained fairly constant for five or eight hours at a time, for it was independent of the heating of the sun and largely dependent upon the altitude of the planet. These circumstances, together with several others, occasionally permitted me to see the very delicate markings on Venus with certainty. See the accompanying plate. The boundaries are somewhat too sharp, for the low powers used to secure contrast made the detail look sharper than it really was.

It is necessary to be very cautious in reaching conclusions from objects at the limit of perception. Therefore I tested very thoroughly the reality of the chief marking in these drawings.* One method of testing it was to change the orientation of the image by rotating a prism eyepiece, so that the streak would appear in an entirely unexpected position. The result was very successful, for tests repeated frequently enough to eliminate chance gave values for the position-angle of the streak in remarkably close accordance.†

The prism obviated the possibility that the streak had its origin in the mind, the eye, the eyepiece, or in the prism itself. The streak could not have been in the telescope, for the same marking was unmistakable in each of four different instruments. It could not have been in the air, for the marking was never clearly seen except when the image was almost undisturbed and the diffraction rings sometimes motionless. In other words the streak could have originated nowhere but on the planet itself.

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* No drawings showing this marking at its best have been omitted. But there are also some drawings showing the planet at different phase.

† The best examples of this test are the drawings of June 9 and July 7. These have been mathematically oriented from the original drawings. But the observations of June 12 at 2^h 30^m, July 7 at 1^h 50^m and 2^h 25^m, and July 23 at 4^h 0^m, though not included in this note, confirm the true position of this marking.

But there is still more evidence in favor of this conclusion. The orientations of the image were always referred to the celestial poles instead of to those of the ecliptic. For this reason the long streak shifted apparently through the position angle of thirteen degrees in the interval from June 9 to July 7. I was not aware that my drawings revealed this shift in orientation until I examined them almost a year after the close of my observations.[*]

The drawings of June 21, 23, 24, and July 19 were made without the diagonal, but in the same impersonal way. I made it an invariable rule to do each drawing on a separate sheet of paper, and not to look back on them until toward the close of the observations. Most of the drawings, indeed, looked quite new to me when I re-examined them; and then, for the first time, I saw the successive identity of the chief marking, and discovered that it is well represented in the sketches of the planet made on April 19, 1898, by Douglass and Drew.[†]

The comparison of the drawings with each other leads to a value of the rate of the axial rotation slightly faster than that of the orbital revolution: the indicated elements of rotation are first, a period of 223.9 days and, second, the perpendicular axis accepted by all of the advocates of the long period.

After making this computation I turned to other drawings for corroboration. Nearly all of the better drawings made in the past forty years show a set of certain more or less permanent markings in common, and not only demand the period of 223.9 days,[‡] but contradict the idea of a materially slower rotation.

The probability of accidental coincidence has been carefully studied, and the results have been favorable to the new period. The basis of the 223.9-day period appears to be much firmer than that of the other periods proposed up to now. In the first place the slow rotational shift with reference to the sun is indicated very clearly, although the draw-

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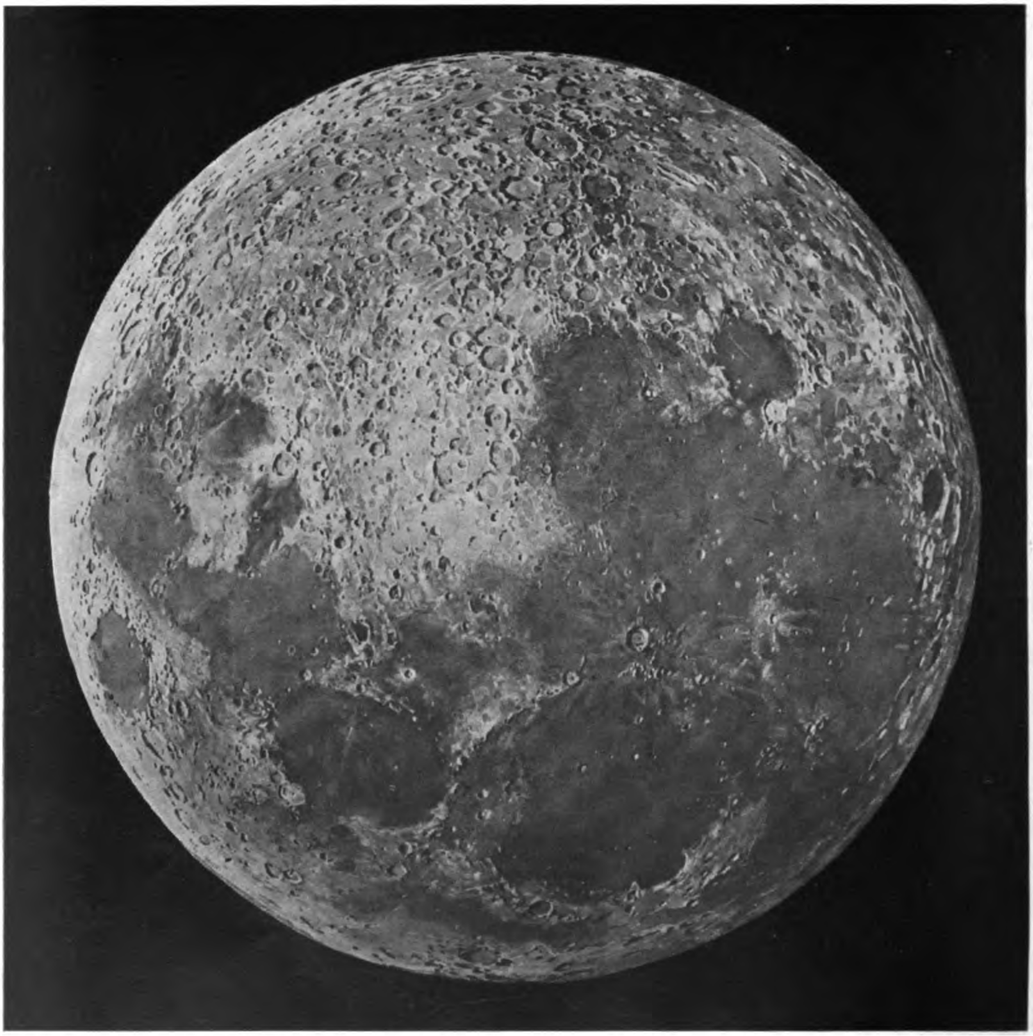
[*] See the first five drawings. The probable error of their mean is thirteen times smaller than the quantity measured. I cannot explain the discordance of July 19 except by an error in the placing of the wire then used to get the bearings of the disk. but the main question is not affected.

[†] Monthly Notices R. A. S., Vol. 58. The possibly illusory nature of the spoke system does not affect the comparison of drawings about to be mentioned.

[‡] Even Schiaparelli's various drawings seem to be no exception to the rule.

PLATE XXXVIII



A NEW PROJECTION OF THE MOON.
For Use As a Guide at the Telescope.
Copyright 1916 by Russell W. Porter.

ings have been selected without regard to where they were made. As the values derived agree not only qualitatively (with respect to the inclination of the axis and the direction of rotation), but quantitatively (with respect to the exact rotational velocity), the chance of accidental coincidence is very small, especially in view of the large number of drawings measured. Again, chance coincidence is the more improbable, for the delineation of the very same object by the different observers shows unmistakably their respective characteristic ways of seeing it. Representations accidentally similar would not show personal equation of the special kind we are concerned with here. Finally, chance coincidence is very improbable, for certain of the drawings, when measured for the period, show a systematic error of just the kind anyone would predict without regard to the period.

Detailed proof will be prepared as soon as possible.

Philadelphia, Pa., 1916, June 29.

A NEW PROJECTION OF THE MOON

For Use as a Guide at the Telescope.

RUSSELL W. PORTER.

One of the first needs of the student taking up the study of the moon's surface is a means of identifying the different features of its topography. Many maps of the moon have been made for this purpose, drawn from a triangulation of several points scattered over its surface, and the topographical detail filled in by hand. They are all of varying degrees of excellence, and represent a vast amount of time and labor.

With the advent of photography it might be thought that a photograph of the moon, taken at full, would provide one with all that could be desired in picking out any particular marking, but such is not the case. Many of the lunar features are completely obliterated at full moon.

For those familiar with lunar photographs or visual work at the telescope, it is known that only along the terminator, or boundary between the lightened and darkened surfaces, does the character of the topography stand out clear and distinct. It will also be noted that any attempt at assembling, photographically, several negatives taken on the terminator and scattered over the entire moon, would be rendered abortive by their different scales and aspects, due to unequal distances of the satellite from the earth and its changes in libration.

However it seemed to the writer that an improvement over the older charts might be effected by preparing a reseau or net work of meridians of longitude and parallels of latitude, carefully locating thereon the main features from a full moon photograph, and then transferring to this skeleton framework, by hand, the details found on the terminator prints. The accompanying chart Plate XXXVIII is the result.

For existing material, the Harvard plates taken at Jamaica in 1900 were drawn upon. They were made with a twelve-inch objective of 135 feet focus.[*] The basis is a photograph of the full moon having a libration in longitude of −3.8 degrees and in latitude of −5.6 degrees The details are from the sixteen plates showing the terminator in as many positions distributed over the moon's disc. The sunrise aspect was preferred over the sunset, as being the more likely to be of use. The orientation is that seen through an inverting telescope.

This projection represents an impossible condition of illumination, viz., that of lunar sunrise at every point of its surface. Yet it must be remembered in preparing a map of this kind, that a compromise of some sort must be accepted.

The writer realizes the futility of the artist in attempting to improve on the accuracy and wealth of detail afforded by modern photography. This was not his intention. It was as a means to assist the amateur at the eyepiece that the effort may be considered as in any way justified.

THE ARISTILLUS TEST FOR THE QUALITY OF THE SEEING.

WILLIAM H. PICKERING.

In the former paper, Popular Astronomy, **24**, 273, it was stated that the interior canal of Aristillus was being examined at the observatory of M. Jarry-Desloges in northern Africa, and that the writer expected from the quality of the work done at that observatory, that the canal would be resolved. In this expectation he has not been disappointed. With this paper he is able to present, Figure 1, a copy of a drawing of the canal, which M. Desloges has been kind enough to forward to him, and which clearly shows the duplication. It may be compared with the drawing by the writer accompanying the above mentioned article, and also with Figure 2 of his first paper on Aristillus; POPULAR ASTRONOMY 1914, **22**, 570. See also the Lowell drawings published in the last February number of this magazine.

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[*] The Moon, by W. H. Pickering (Doubleday Page, N. Y.)

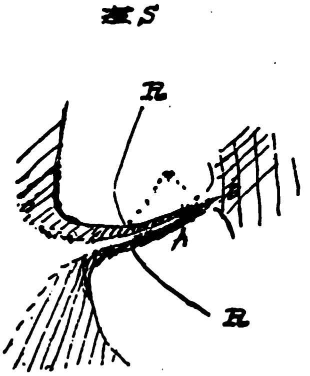


FIG. 1. Aspect general du canal d'Aristillus, entre les onzieme et dixneuvieme jour du lunaison.

A comparison of the drawings made at these three observatories is interesting, because it is probable that they are the only ones in the world where a resolution of this canal is possible at the present time, It might be done at Arequipa, but excepting for photometric work no visual observations have been made there for over twenty years. It might possibly be done at Tucson, but the aperture there, only eight inches, is pretty small for such a difficult object. It is not likely that it could be done at the Mt. Wilson Solar Observatory, because the aperture of the sixty-inch intercepts too large a column of air to be homogeneous, and if the aperture were reduced to twelve or eighteen inches, the large hole in the mirror would seriously interfere with the success of the observation. There is a bare chance that if one of the very fine nights that Mr. Phillips occasionally secures at Epsom, England, should occur when Aristillus was favorably situated, he might double the canal, but this seems rather unlikely. Professor Aitken has already given it up at the Lick, and it is doubtful if the seeing is ever good enough at the Yerkes to show it. It is perhaps scarcely worth while to look for the phenomenon elsewhere, but in case any other astronomer

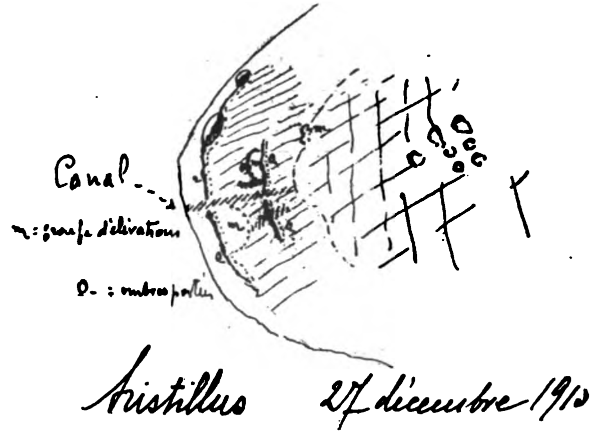


FIGURE 2.

should succeed in resolving it, I hope he will not hesitate to publish the fact, since it is very desirable to know where all the observatories possessing really good seeing are located. On the other hand it is likely that there are a number of observatories where the two outer canals are occasionally visible, and a distinct view of them involves no mean order of seeing, and is worthy of mention.

Referring to the drawing, M. Desloges does not give the date on which it was made, but says it represents the appearance between the eleventh and the nineteenth days of the lunation. This would be in general between colongitudes 40° and 140°. He says "The dark lines of the canal are straight, and the duplication difficult to see, especially towards A and even beyond the crater rim." The writer has inserted the two Rs on the drawing, to indicate the rim. Again he says "The canal appears sometimes to extend only to B, and again sometimes to be prolonged by a greyish zone." See Figure 3 of my earlier paper. He has also forwarded a drawing made on December 27, 1915, colongitude 159°.3. after the canal had again become single. This is shown in Figure 2, This drawing, as he states, shows some very delicate detail, which other astronomers may be interested to verify.

Mandeville, Jamaica, B. W. I.

THE SKIES OF HALLOWEEN.

CHARLES NEVERS HOLMES.

The Harvest and Hunter's Moons are still remembered; but the full Moon of November is three weeks in the future. Over hill and vale we see the blight of early frost; flowers have disappeared, plants have withered, meadows look lifeless. But, under the cheerful rays of October's sun, the foliage of forest and field shines bright in gold and bronze, relieving the depression of a sombre autumnal landscape. Now and then we feel the breath of some colder breeze, suggestive of approaching winter, and the dead, brown leaves at our feet whirl and dance as though suddenly resurrected into life. But King Sol is descending lower and lower, his fiery face passes from sight, a few small clouds reflect his hidden presence, and gloaming settles slowly upon knoll and valley. The day is done—Halloween has come!

One by one, the suns of night awake, to take the place of King Sol. Blue, brilliant, beautiful Vega sparkles towards the westward, and not far distant firmamentally Altair of Aquila glitters against the dim, remote background of the Milky Way. In the northeast Queen Capella is rising, escorted by winter's brilliant galaxy—the red eye of Aldebaran flashing near the horizon, the tiny group of Pleiades shining higher up. Clearer and clearer appear the suns and constellations of night: the Northern Cross, now descending towards the westward; the great square of Pegasus, below the zenith; the Dipper, at present far to the north; Cassiopeia's Chair, Perseus, Aries, Pisces, Cetus, Aquarius, Capricornus; sun after sun, constellation after constellation, awakening to scintillate and twinkle amid the darkened depth of an illimitable Universe.

And, now, the dome of night is gloriously ablaze with innumerable stars. Sparkling, flashing like celestial gems, they are revolving around and around Polaris, sun-pivot of our firmament. Like a vast sidereal clock are these stars and constellations above us, their respective sky-positions indicating accurately the hour of night. Supernal beacons, also, are they; lighting the darkness of stupendous space. Fiery firmamental furnaces, illuminating and heating the satellites that revolve around them. Like glittering, glowing eyes that never close until King Sol awakens once more in the east. Thousands of such sky-gems are visible to man's unassisted sight; and millions are visible through eyes of powerful telescopes or printed upon photographic plates. A space of hundreds of light-years occupied by multi-myriads of fiery suns and their solar systems. A universe as illimitable as the law and power of Gravity!

Yonder is the Milky Way, shining with its innumerable suns. What is the exact number of those very remote stars? What is their exact distance—how wide is that luminous girdle, visible alike from our northern and southern hemispheres? What is the real reason for its mysterious presence? Where are we of a tiny planet situated with respect to this so-called Milky Way? Are we nearer to that part of the Milky Way seen from our southern hemisphere than we are from that part viewed from our northern hemisphere? Above us, all around our earth, this dimly shining circle of myriad suns is visible, surrounding like some titanic sidereal frame innumerable stars and star-systems. Why is it there?—for what purpose exist the suns and satellites within it?—what know we of the Universe that lies beyond the confines of our remote Milky Way?

Time passes, and we see some planet, shining placidly amid the darkened firmament. Millions of miles distant, yet how near that shining body seems after such a stupendous excursion into illimitable space! Like a veritable solar mirror, framed by the darkness of night. Like a golden gem set amid sparkling, fiery diamonds. A world belonging to our own system, surrounded by its revolving satellites. Shining with the steady light of hidden King Sol, that placid planet reflects those solar rays to our earth. A passive celestial body, not to be compared with any one of the myriad suns sparkling and scintillating above us.

The skies of Halloween!—The darkened firmament, just as October passes into November. On earth, there is hereabout the spirit of weird imagining—another revival of an old custom. Goblins and witches return to life; eerie fancies become realities. Fearsome shapes and shadows lurk all around us. It is indeed an evening of childhood memories and old-time traditions. But, overhead, the suns of night are twinkling in splendor—wholly unchanged. Blue Vega, bright Altair, are descending towards the westward; brilliant Capella, ruddy Aldebaran, are ascending out of the, eastward. The less conspicuous stars of autumn are about to be replaced by the more conspicuous stars of winter. It is a sort of sidereal interim. The suns and constellations of Halloween are sparkling above us; the same suns and constellations that gleamed and glittered when we were children, many, many years ago!

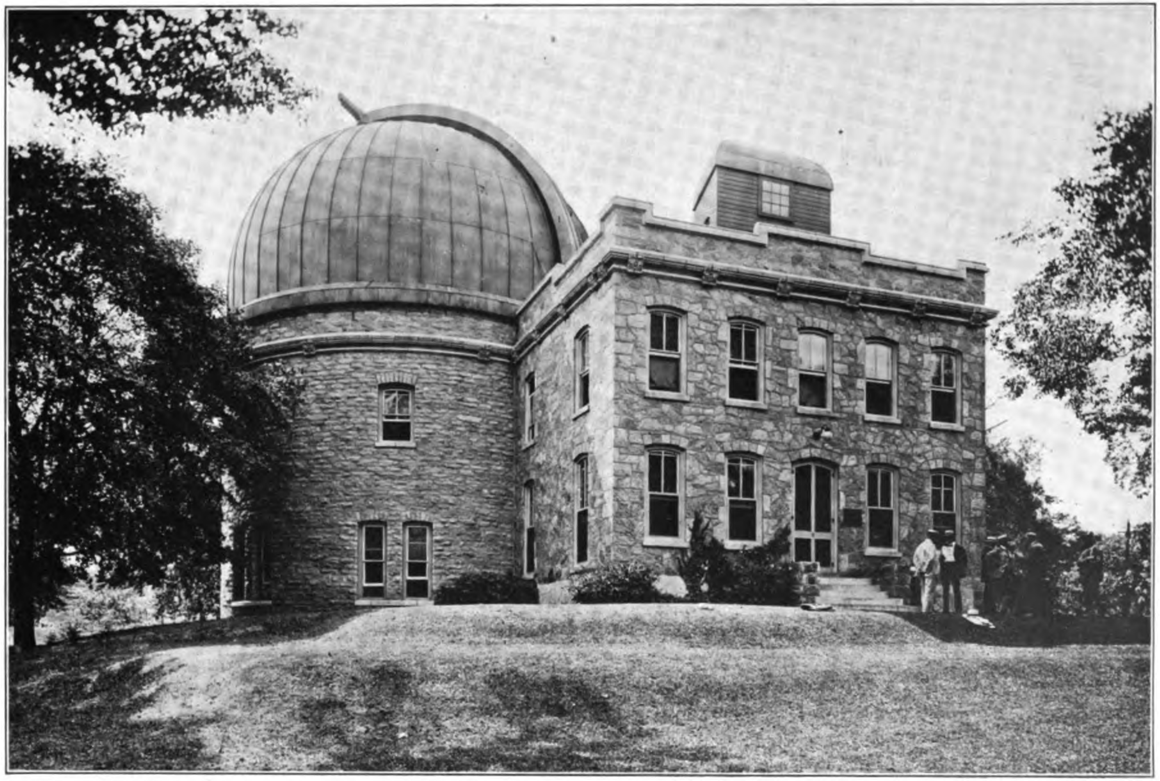
Windsor House.
Gardner, Mass.

NINETEENTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

The nineteenth meeting of the American Astronomical Society was held at Swarthmore College, Swarthmore, Pennsylvania, on August 30 to September 2, 1916. The plan of housing the members in college dormitories, used at Evanston, was adopted here, with similar comfort and pleasantness. The college dining room was opened to accommodate the Society. As all meetings were held in the Sproul Observatory, the sleeping quarters, dining room, and meeting place were all within two or three minutes walk of each other.

It was particularly happy that we could be greeted to Swarthmore College by its President, Dr. Joseph Swain, once a student of Astronomy under Piazzi Smyth. We may be privileged to doubt whether his knowledge of Astronomy is as completely dissipated as he would have us suppose. We prefer to believe that, while it may have merged into the background of broadened scholarship, the interest in Astronomy might again call it forth to attack with success the new problems. In any case, the interest was so genuine and his welcome so cordial that

PLATE XXXVI



THE SPROUL OBSERVATORY

it was a pleasure to us all to be at Swarthmore. He recalled his early association with Professor Miller, at the University of Indiana, and specifically the action of the Trustees on Professor Miller's request for a new telescope which should be of nine inches or, if possible, of twelve inches aperture. He spoke of Professor Miller's discomfiture when the Trustees, in bantering spirit, informed him that they did not find it possible to grant his request for a nine-inch refractor, and his joy when, a few minutes later, they announced that he might have a twelve-inch telescope. A somewhat similar episode occurred on his coming to Swarthmore, at which time he had asked for an eighteen-inch, or better, a twenty-four inch telescope. The Honorable Senator William Cameron Sproul, who provided the funds for the twenty-four inch refractor, reviewed the incidents leading up to his gift. He paid a glowing tribute to his former teacher, Miss Susan J. Cunningham. She seems to have impressed the love of truth and learning on her students in an extraordinary degree. In this case it is bearing ample and very substantial fruit.

President Pickering replied to these addresses of welcome, and the meeting started off pleasantly, and with a feeling of great cordiality.

The scientific program was divided into six sessions: Wednesday morning at ten o'clock, and afternoon, at two o'clock; Thursday at the same hours; Friday morning at nine, and Saturday morning at half after nine o'clock. Fifty-two papers were presented, and also reports from various committees. Certain reform must soon be made in our program, for the various meetings show an increasing number of papers, and soon our sessions will be seriously overburdened with their presentation, crowding out opportunity for discussion, committee meetings, and general conference, which, after all, are the most valuable part of the meetings.

Several very enjoyable social features were provided for our entertainment. On Wednesday evening, Mr. and Mrs. Miller invited us to their home, where, at a reception, we had the opportunity to see their pleasant home, and to meet many of their friends and neighbors. On Thursday evening, we were driven in automobiles to the home of Senator Sproul, Lapidea Manor, where he and his wife received us most cordially. After a stroll about the grounds, from which we had a fine view across the low rolling hills to Chester, we sat down to what was styled a "Pennsylvania Country Supper." President Joseph Swain, President Isaac Sharpless of Haverford, and Provost Edgar F. Smith of the University of Pennsylvania, as well as other guests, friends of the College and Observatory, were with us. We spent the evening inspecting the many art and antique treasures of the Sproul home.

On Friday at noon we were taken in hand by a group of Swarthmore citizens, who took us in their automobiles on an excursion to historic Valley Forge, of which it is written, "No spot on Earth—not the plains of Marathon, nor the passes of Sempach, nor the place of the Bastile, nor the dikes of Holland, nor the moors of England—is more sacred in the history of struggle for human liberty." We visited here the various points of interest, and saw the many relics and memorials. Of especial interest at this time, when most of the world is represented by thousands of soldiers burrowing in trenches, were the still clearly visible lines of entrenchments prepared by Washington's army. The day was rather warm, and it required somewhat of a stretch of imagination to picture the sufferings from the cold of the ragged and poorly shod and famished continental army, Our way on the return took us through the campus of Bryn Mawr College. We drove into the quadrangle, and looked about at some of the buildings. It is certainly a most attractive place, even without the young ladies—for school was not in session—harmonious and beautiful in detail and ensemble. Leaving Bryn Mawr, we went on to Haverford College, and found ourselves in surroundings no less beautiful than we had left. Fine lawns, beautiful trees, and adequate buildings characterize the place. It was pleasant to be welcomed by another Astronomer President, President Isaac Sharpless. Professor E. W. Brown, by virtue of his earlier connection with the College, took the lead, and conducted us to a bower where tea was served, very refreshing after our rather dusty ride. Several members of the Haverford faculty showed us about. Naturally, we took great interest in the Observatory, with its nicely cared for ten-inch equatorial and other instruments, and the monument marking the site of the first Observatory of Professor John Gummere. Finally, on this day of many experiences, we reached the Flower Observatory, at Upper Darby, and were greeted by the Provost of the University, Dr. Edgar F. Smith, and Mrs. Smith, and by the Director, Professor Eric Doolittle, and his wife, and by his predecessor, his father, Professor C. L. Doolittle, and his wife. Certainly there is nothing more worth while seeing than a son so well qualified to be the successor of his father, and a father so worthy of being followed, together.

We were the guests of the University of Pennsylvania for the dinner which was spread under the great trees on the Observatory grounds. The long ride had given us the appetite which is the best spice for food. It was a beautiful evening, after a glorious day, but unfortunately clouds soon covered the sky, and denied us more than a mere glimpse of the stars with the eighteen-inch refractor. Most of the party, after tarrying an hour after dinner, returned to Swarthmore; but a few, in the hope that it might clear, or, failing that, in the wish to see how

Professor Doolittle is caring for the task inherited from Burnham—the custodianship of double star literature—stayed on, and had a very pleasant evening, returning to Swarthmore in the middle of the night.

Among the various features offered for our comfort at Swarthmore, must be mentioned a swimming pool which provided both refreshment and entertainment. One of us, having hung his clothes within a locker, unwittingly twirled the lock, and returning from the pool, found himself unable to solve the combination. I have no doubt that application of the principles of permutations and combinations might eventually have won him his clothes; but a screw-driver was more immediately successful. Meanwhile, inquiry was set on foot as to whether there was a cooper present, and also a lively discussion arose as to just the degree of informality of Senator Sproul's dinner.

On each evening, the dome was opened, and the telescope was placed at the disposal of the visitors, for the observation of such objects as we might wish to view. Either Mr. Pitman or Mr. Mátos was present to manipulate the telescope. As the seeing was not at its best, it was not possible to test severely the quality of the objective. Clusters, nebulae, double stars and the planets Jupiter and Uranus, were exhibited. It was possible for us to see three of the satellites of Uranus. There seems to have been a marked change in the relative brightness of Oberon and Titania on the two nights of August 30 and September 1, Oberon being apparently much fainter on the second night than on the first. For those observers who have had the experience in observing with large telescopes, and have had the convenience of a rising floor, the lack of it at Swarthmore was very emphatic. The rising floor, which is a convenience for small instruments, becomes almost a necessity for large ones.

At the sessions of the Council, some changes were made in the matter of Committees. In accordance with the recommendation of Professor Townley, Chairman, the Committee of Variable Star Nomenclature was discharged. His statement is as follows: "The Committee has not been able to find any common ground on which to stand. Miss Cannon favors the Harvard system of nomenclature, Professor Russell favors the continuation of the present Argelander system, and the Chairman favors the number system. Under these circumstances, the Committee is not able to make progress, and I would suggest that it be discharged." In compliance with the recommendation of Professor Campbell, Chairman, the Committee on Coöperation in the Observation of Radial Velocities of Stars, was discharged. He stated that the 1912 report complied with all the purposes of the act which led to the appointment of the Committee; in short, that the Committee found that coöperation was impractical. This was not the unanimous opinion, but the prevailing one. The Comet Committee, under the chairmanship of Professor Comstock, having very effectively accomplished its purpose, was ordered discharged, and it was also ordered that the undistributed reports be deposited with the Secretary. A final report of the Committee is given at the end of the account of this meeting.

In view of the coming favorable solar eclipse of June 8, 1918, a Committee was appointed to further and facilitate the coöperation among the members of the Society, and others, for its observation. The personnel of the Committee is as follows: Messrs. W. W. Campbell, Chairman, E. E. Barnard, F. B. Littell, Frank Loud, S. A. Mitchell, and Edison Pettit. The Committee was given power to add to its membership. The Committee on Meteors was enlarged by the appointment of C. P. Olivier, Secretary, E. E. Barnard, W. J. Humphreys, F. R. Moulton, and W. H. Pickering. Professor A. O. Leuschner was appointed Chairman of the Committee on Asteroids, in place of Professor E. W. Brown, who had resigned.

A proposal for the enlargement of the Society by instituting the grade of Associate member was presented by Professor Schlesinger. A Committee of the Society had considered such a proposal, and at the Atlanta meeting, reported in favor of the retention unchanged of our present system. However, a committee, consisting of Messrs. Frank Schlesinger, Chairman, C. A. Chant, G. C. Comstock, Philip Fox, W. T. Olcott, and E. D. Roe was appointed to give the proposal consideration.

At the Atlanta meeting of the Society, it was voted to endeavor to meet with the American Association for the Advancement of Science, at its proposed general quadrennial meetings. Inasmuch as the first of these great quadrennial meetings is to be held in New York, in the coming December, it was decided to comply with the vote made at Atlanta, and meet with the Association in New York, on December 26 to 30, 1916. Further, it was decided, accepting the invitation of Professor Benjamin Boss, to hold the annual meeting of 1917 at the Dudley Observatory, in Albany, New York, in the summer of 1917, the date to be fixed by the Executive Committee and Professor Boss.

At the last meeting of the Society, Professor Schlesinger presented the following resolution, which was unanimously adopted:

> WHEREAS: In the death of Karl Schwarzschild on May 11, 1916, many of the members of this Society have lost a warm friend, the Society itself one of its most eminent members, and Astronomy a brilliant and remarkably versatile contributor;
>
> *Resolved*: That the Society record in its minutes its sense of deep loss, and that copies of this resolution be engrossed and sent

to Mrs. Schwarzschild, and to the Astrophysical Observatory at Potsdam.

Twenty-seven new members were elected to membership in the Society, as follows:

H. C. Bancroft, 412 Taylor Avenue, West Collingswood, N. J.
Ruth D. Bannister, Pisgah, Iowa.
Arthur Floyd Beal, Albion College, Albion, Mich.
Martha Clare Borton, Princeton Observatory, Princeton, N. J.
Frederick Lyons Brown, Dearborn Observatory, Evanston, Ill.
Allan B. Burbeck, North Abington, Mass.
Clifford Charles Crump, Carleton College, Northfield, Minn.
Edith Eleanor Cummings, Laws Observatory, Columbia, Mo.
Clinton Harvey Currier, Brown University, Providence, R. I.
William Ewart Glanville, St. Peter's Rectory, Solomons, Md.
Edward Gray, 2635 Channing Way, Berkeley, Cal.
William Le Roy Hart, Harvard University, Cambridge, Mass.
Francois Henroteau, Detroit Observatory, Ann Arbor, Mich.
William T. Herriott, Allegheny Observatory, Pittsburgh, Penn.
Kiyotsugu Hirayama, Astronomical Observatory, Tokyo, Japan.
Arthur S. King, Solar Observatory, Pasadena, Cal.
Ora Miner Leland, 150 Triphammer Road, Ithaca, N. Y.
C. B. Lindsley, 855 East Ridgeway Ave., Cincinnati, Ohio.
Walter A. Mátos, 309 College Ave., Swarthmore, Penn.
Harriet McWilliams Parsons, Vassar College, Poughkeepsie, N. Y.
Jesse Pawling, Naval Observatory, Washington, D. C.
Edison Pettit, Washburn College, Topeka, Kan.
David B. Pickering, 81 South Burnett St., East Orange, N. J.
William Francis Rice, Wheaton College, Wheaton, Ill.
Robert Trümpler, Allegheny Observatory, Pittsburgh, Penn.
J. van der Bilt, Utrecht Observatory, Utrecht, Holland.
Reynold K. Young, Dominion Observatory, Ottawa, Canada.

On the last day of the meeting, officers were elected as follows:

President	E. C. Pickering
First Vice-President	Frank Schlesinger
Second Vice-President	W. W. Campbell
Treasurer	Annie J. Cannon
Councillors for 1916-18	E. W Brown J. S. Plaskett

The following officers continue in service:

Councillors, 1915-17	Edwin B. Frost Joel Stebbins
Secretary	Philip Fox

The meeting brought out a wellnigh record attendance, exceeded only at the seventeenth meeting. The following members were present:

Leah B. Allen
A. T. G. Apple
S. G. Barton
L. A. Bauer
A. F. Beal
Harriet W. Bigelow
E. W. Brown
Annie J. Cannon
C. A. Chant
W. A. Cogshall
R. H. Curtiss
C. L. Doolittle
Eric Doolittle
J. C. Duncan
W. S. Eichelberger
Edgar Frisby
Philip Fox
Caroline E. Furness
W. E. Harper
Margaret Harwood
Wm. T. Herriott
Francois Henroteau
Kiyotsugu Hirayama
Mary M. Hopkins
Charles J. Hudson
Louise F. Jenkins
C. C. Kiess
O. M. Leland
Walter A. Mátos
Paul Merrill
Willis I. Milham
John A. Miller
S. A. Mitchell
C. P. Olivier
Edison Pettit
E. C. Pickering
John H. Pitman
John M. Poor
A. W. Quimby
E. D. Roe, Jr.
H. N. Russell
Frank Schlesinger
Frederick Slocum
M. B. Snyder
Joel Stebbins
Hanna B. Steele
H. T. Stetson
Florence J. Stocker
Helen M. Swartz
John Tatlock
Stephen D. Thaw
A. B. Turner
Robert Trümpler
F. W. Very
J. van der Bilt
A. van Maanen
W. R. Warner
D. T. Wilson
W. L. Wright
C. C. Wylie

In addition to the members, there were many visitors:

Ida M. Barney, Marie Bender, Susan J. Cunningham, Mrs. Edgar Frisby, Mrs. Izette F. Hudson, B. H. Lamont, H. A. Markley, Mrs. S. A. Mitchell, Mrs. J. A. Miller, Susan M. Rambo, Susan Raymond, Mrs. Frank Schlesinger, Mrs. Frederick Slocum, Mrs. H. T. Stetson, Mrs. Stephen D. Thaw, Mrs. A. B. Turner, President Joseph Swain of Swarthmore College, President Isaac Sharpless of Haverford College, Provost Edgar F. Smith of the University of Pennsylvania, and Senator William Cameron Sproul.

At the final meeting, Professor E. W. Brown presented the following resolution of appreciation of courtesies:

Resolved: That the Astronomical Society express to the President and Board of Managers of Swarthmore College, its thanks for the courtesies extended to the members of the Society during the meetings at Swarthmore. The Society desires also to express its appreciation of the numerous arrangements made for their comfort and convenience by Professor Miller and President Swain and of the manner in which these have been carried out by the Matron of Wharton Hall and others who have assisted in looking after the welfare of the visitors.

Resolved: That the thanks of the Society be extended to Senator William Cameron Sproul, to the citizens of Swarthmore, to the President and Trustees of the University of Pennsylvania, and to the President and Board of Managers of Haverford College for their hospitalities in connection with the visit of the Society and its appreciation of the courtesies extended to its members.

Resolved: That the Secretary be directed to communicate the substance of these resolutions to Presidents Swain, Smith, and Sharpless, and to others who have assisted.

Less formally, Professor Schlesinger, the First Vice-President, at our last luncheon on Saturday noon, expressed to our hosts very happily, the general appreciation.

At the close of the meetings, the visitors hastened their departure, to reach their several destinations before the threatened railroad strike might be an actuality.

ABSTRACTS OF PAPERS.

RECENT STELLAR SPECTROSCOPIC RESULTS.

By Walter S. Adams.

The method of determining stellar parallaxes from relative line intensities in the spectra of stars has been applied to several groups of stars with measured parallaxes. These results may be summarized as follows:

1. The parallaxes of 28 stars of small proper motion have been determined recently by van Maanen with the 60-inch reflector of the Mount Wilson Observatory. Of these 17 have parallaxes of less than +0″.02, the average value being +0″.008. The spectroscopic method gives an average value of +0″.010. Seven of the remaining stars have an average measured parallax of +0″.034: the spectroscopic value is +0″.023. In the case of the remaining four stars the spectroscopic parallaxes are lower than the measured values ranging between +0″.06 and +0″.10.

2. The parallax of the stars belonging to the Hyades group may be calculated with high precision from the motions within the group. Kapteyn's value of the parallax is +0″.024. Spectrum photographs of the four brightest stars yield an average absolute magnitude of +0.3, or a parallax of +0″.020.

3. Barnard's large proper motion star is found to have a spectrum of type Mb and to belong to the "dwarf" class of M stars. Its parallax as estimated from the spectrum should be of the order of +0″.2. Its radial velocity is −93 km.

4. The spectroscopic parallaxes of 27 stars of large proper motion are found to be in good agreement with the measured values. The measured parallaxes range from +0″.02 to +0″.27, and the spectroscopic results show an average deviation of 0″.026.

Determinations of radial velocity at Mount Wilson have yielded a total of 48 stars with radial velocities, corrected for the Sun's motion, exceeding 50 km. The spectral types of these stars are as follows: A, 7; F, 7; G, 18; K, 9; M, 7. The stars with the very highest velocities are found in the first three types. Nearly all of the A type stars in this list are peculiar in that the characteristic magnesium line at λ 4481 is absent or very faint. It seems probable that this is related to the low absolute magnitude of these stars. The ninth magnitude star BD +18°3423 of type A9 has a radial velocity of −240km. The cluster variable *XZ Cygni* has a velocity of −150 km with a moderate variation. Its spectrum varies from about A0 at maximum to A8 at minimum.

The spectroscopic binary Boss 46 has a composite spectrum both components showing the helium lines. The maximum separation so far observed is about 400 km, with the H and K lines showing little or no variation. The period is probably of the order of two days and is under investigation.

ON THE CALIBRATION OF THE PHOTOMETER WEDGE OF THE LEANDER McCORMICK OBSERVATORY

By Harold L. Alden.

The calibration curve of the photometer wedge of the McCormick Observatory derived from recent measures, (1914-16), shows an undoubted change from that obtained from the earlier data, (1900-1905). The maximum amount of the change is less than a quarter of a magnitude, the difference being mainly in the thinner portions of the wedge. This change is in the direction that would be produced by a deterioration of the photographic film. It is probably due partly to this, and partly to changes in the adjustments of the photometer.

A SMALL STAR WITH THE LARGEST KNOWN PROPER MOTION.

By E. E. Barnard.

As the title implies the paper deals with the discovery of a star of the eleventh (photographic) magnitude with a proper motion of 10″.3 a year. Visually the star is of about the tenth magnitude. It is in the constellation of Ophiuchus and follows the star BD + 4°3560 by about 9^s and is north 1′. It is in the mean position

$$1916.423 \quad \alpha = 17^h\ 53^m\ 43^s.60 \quad \delta = +4^\circ\ 27'\ 48''.0$$

Adams, at the Mount Wilson Solar Observatory, finds that the spectrum of the star is type Mb (H.C.O. Classification) and that the radial velocity is −93km. He also finds from its spectrum that its parallax is + 0″.2.

THE INTERRELATION OF THE ASTEROID ELEMENTS.

By Samuel G. Barton.

Lantern slides were exhibited showing the variations in the average value of each other element as the 806 asteroids are arranged in small groups with each element in turn increasing. The effects of the secular perturbations of the orbits by Jupiter appear. There are 47 asteroids which have mean daily motions between 1025″ and 1119″ and everyone has an inclination under 6°.8 whereas the average inclination of all is 9°.6. The mean daily motion is very large for asteroids with inclinations of 5°. The mean daily motion and the eccentricity increase with increasing inclination. The asteroids are about uniformly distributed as to size.

NOTE ON ROTATION PERIODS OF PLANETS.

By L. A. Bauer.

The question as to the possible existence of cosmical effects arising from planetary magnetic fields is engaging the attention, at present, of various investigators. The first step is to determine, if possible, the relative strengths of the magnetic fields supposed to envelop the members of our solar system. Assuming that the magnetic fields result from the fact that the bodies which they envelope rotate about certain axes, the author has deduced a theoretical formula* which yields for example, a value for the magnetic field strength of the Sun agreeing within 10 per cent of Hale's observed, provisional value. The formula involves the following quantities: ω, the angular velocity of rotation; r, the mean radius of the body; d, the mean density, or, instead of the latter, g, gravity at the surface. These quantities being known, the formula gives the magnetic field strength of a planet relative to that of the Earth, a known quantity. It is thus seen that the question of the rotation periods of planets, as also the direction of rotation, is one of interest to the student of cosmical magnetism. Unfortunately only in the case of half of the planets, namely, the Earth, Mars, Jupiter, and Saturn, is the the period of rotation definitely known.

In putting together all known facts regarding the planets, it was noticed that for the four named the product ωv, in which ω is the angular velocity of rotation and v the orbital velocity of the planet, could be regarded as a constant quantity within about fifteen per cent of its mean value. Thus taking ωv as unity for the Earth, we have for Mars, 0.80, for Jupiter 1.05, and for Saturn 0.76; the mean value for the four planets is at present 0.90.

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* See *Phys. Rev.*, Ser. 2, Vol. 7, p. 500, 1916; the paper containing the formula was given at the New York meeting of the American Physical Society, February 26, 1916.

ON THE PROGRESS OF THE NEW LUNAR TABLES.

By Ernest W. Brown.

It was stated that over 400 pages of the tables were already printed off and that it was hoped that the printing might be completed within the ensuing twelve months. It is expected that the ephemeris for the year 1923 will be completed in time for its insertion in the Almanacs of that year. Some details concerning the presswork, the use of the tables, and the cost of the undertaking were also communicated to the Society.

DETERMINATION OF WAVE LENGTHS BY INTERFERENCE.

Keivin Burns, W. F. Meggers, P. W. Merrill.

The wave-lengths of 400 lines in the spectrum of the iron arc between the limits λ 3233 and λ 6750 have been determined at the Bureau of Standards by interference methods. The accuracy attained is about one part in 2,000,000 or 0.001 Å to 0.004 Å. In most parts of the region there is a line so determined every 10 to 15Å. The fineness of lines as determined from the highest order of interference which they will stand, has been compared with their pole effect displacements with interesting results. These data on the iron lines have been published in Scientific Paper No. 274 of the Bureau of Standards.

Astronomers have been interested in the rare gases as possibly furnishing convenient comparison spectra, particularly in the red region. Wave-lengths in these spectra are being measured by interference at the Bureau of Standards. Three red lines have been measured in the helium spectrum; numerous lines in the neon spectrum from λ 5852 to λ 7245; in the argon (red) spectrum from λ 6965 to λ 8440. These long wave-lengths are easily reached by treating ordinary photographic plates with dicyanin. In a preliminary survey in the first order of a twenty-one foot grating Mr. Meggers has photographed numerous lines in metallic spectra between λ 8000 and λ 9600.

CO-OPERATION IN VARIABLE STAR OBSERVING.

By Leon Campbell.

The study of variable stars has, for nearly a century, proved a large and fruitful field for research. Numerous determinations of their light have been made by visual estimates, especially so by the step-method perfected by Argelander and the method of direct estimates later adopted at Harvard. This has proved particularly applicable to the variables of long period and large range, while photometric methods have generally supplanted it in the case of the short periods and those of small range.

Observations of a large number of long period variables have been made at the Harvard Observatory for more than twenty-five years, and from time to time, a number of amateur and semi-professional observers have greatly aided in the work. For some years past the Variable Star Section of the British Astronomical Association has been conducting an earnest campaign along the same line and has secured valuable results for about 30 of these stars, on the Harvard scale of magnitudes, and more recently their list has been extended to include about 50 stars. They have already published 20,000 observations and have about 16,000 more in preparation for printing. The Harvard Observatory has published to date some 49,000 and is preparing to print about 15,000 more, secured in the past five years by the regular staff and coöperating outsiders.

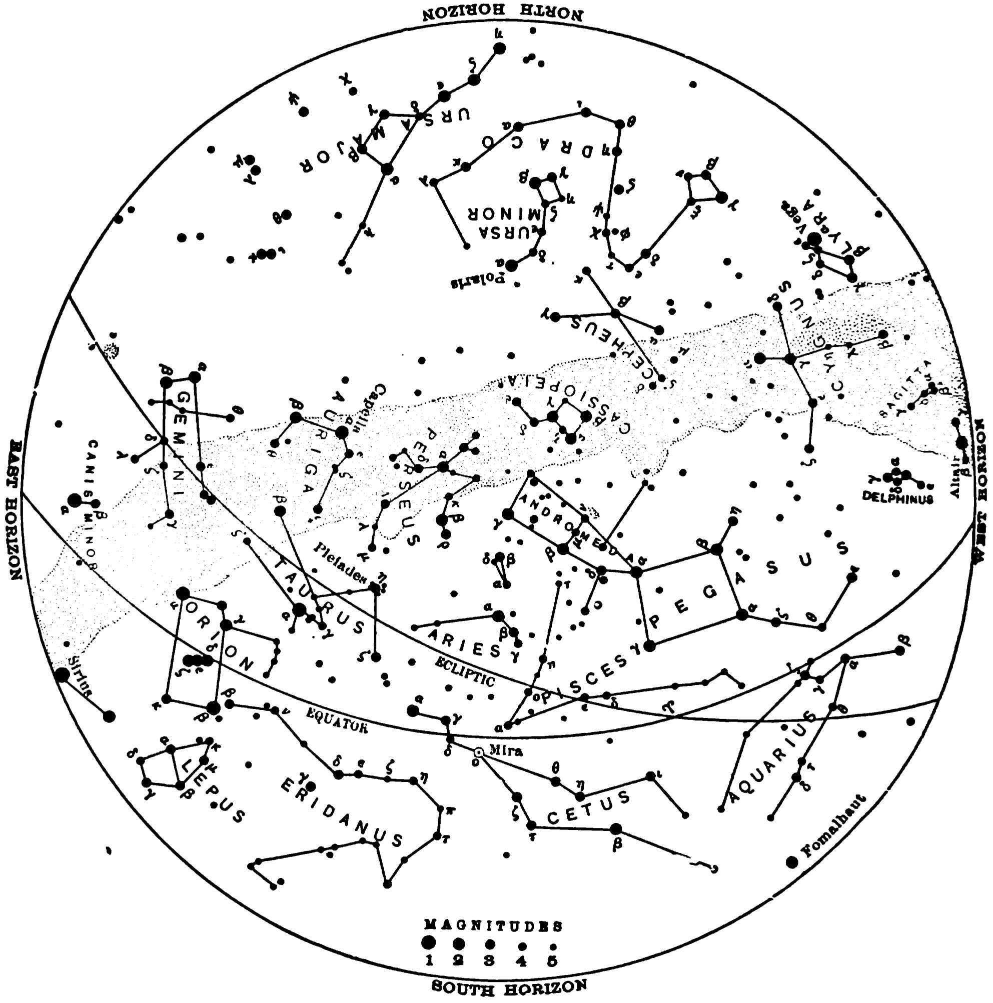
The formation of the American Association of Variable Star Observers in 1911 added another source of aid in this work, and already they have made a splendid record. About 58,000 observations have been obtained through their efforts and all of these have been published in the monthly issues of Popular Astronomy. Thus we have available for the discussion of about 300 variables something like 89,000 observations made during the past five years and the greater part of this due to our American Observers.

It seems desirable that provision should be made for the regular observation of these variables when faint, in large telescopes and that the present plan for the study of the northern variables of long period should be extended to the southern skies. This can best be accomplished by still closer coöperation on a well defined basis and, if possible, by extending to our American Variable Star Observers the support, or endorsement, of the American Astronomical Society, for it would be a pity to see it decline through lack of due appreciation by the scientific world.

(To be continued.)

PLANET NOTES FOR DECEMBER, 1916.

The sun will move southward until December 21, the date of the winter solstice. After this date it will move northward. Its motion among the stars is in an eastward direction moving from Scorpio into Sagittarius. It will not be near any bright star during the month. A partial eclipse of the sun will occur on December 24. It will be visible only in the regions south of Africa.



THE CONSTELLATIONS AT 9:00 P. M. DECEMBER 1.

The phases of the moon for December are as follows:

				h	m		
First Quarter	Dec.	1	at	7	55.5	P.M.	C.S.T.
Full Moon		9	"	6	43.9	A.M.	"
Last Quarter		17	"	12	6.4	P.M.	"
New Moon		24	"	2	31.2	P.M.	"
First Quarter		31	"	6	7.2	A.M.	"

Mercury will move in an easterly direction and on December 31 it will be found near the eastern boundary of Sagittarius, Its distance from the sun will be gradually increasing and shortly after the middle of the month it may be seen in the early twilight.

Venus will still be in the morning sky. At the beginning of the month it may be found near the western boundary of the constellation Libra and at the end of the month near the western boundary of Ophiuchus. On December 28 it will be about 5° north of Antares. Because of its increasing distance from the earth its brightness will be constantly diminishing.

Mars will be low in the western sky setting about an hour after sunset on the 15th. It will be about as bright as Polaris and therefore not easily observed in the twilight. Its actual distance from the earth is increasing. During the month it will move eastward in the constellation of Sagittarius. On December 22 Mercury and Mars will be in conjunction.

Jupiter may be found in the eastern part of Pisces in almost the same position with regard to the stars as it occupied last June. It will be in a good position for evening observation during the entire month.

Saturn will be getting into a position for evening observation as the month progresses. It will be found in the constellation of Cancer.

Uranus may still be seen in the evening sky but it is getting too low in the west for effective observation. On December 12 it may be found near ι Capricorni.

Neptune will be found in the constellation of Cancer just a little east of Saturn Its stellar magnitude is 7.7

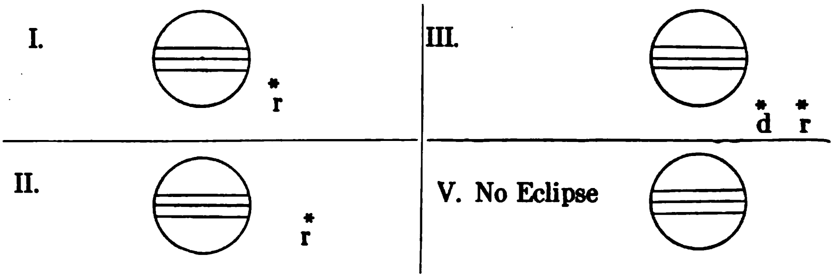
Occultations Visible at Washington.

				IMMERSION.			EMERSION.			
Date 1916		Star's Name	Magnitude	Washington M.T.		Angle f'm N.	Washington M.T.		Angle f'm N.	Duration	
				h	m	°	h	m	°	h	m
Dec.	2	22 B Piscium	6.4	3	4	13	3	53	282	0	50
	2	16 Piscium	5.7	11	32	98	12	20	209	0	49
	5	47 B Arietis	6.5	11	53	72	13	8	252	1	15
	6	ε Arietis(Mean)	4.6	10	55	136	11	34	190	0	39
	7	27 Tauri	3.7	8	9	10	8	48	310	0	39
	7	36 Tauri	5.6	16	46	124	17	34	236	0	47
	8	k Tauri	5.6	16	35	174	16	49	199	0	14
	11	149 B Gemin.	6.4	9	2	166	9	36	207	0	24
	11	79 Gemin.	6.3	20	31	80	21	17	320	0	47
	14	83 B Leonis	5.9	14	42	102	16	3	330	1	21
	14	89 B Leonis	6.2	16	51	161	8	3	274	1	12
	14	π Leonis	4.9	18	22	136	19	39	295	1	17
	16	e Leonis	5.1	20	54	191	21	22	235	0	29
	18	370 B Virginis	6.0	13	43	82	14	32	338	0	49
	26	π Capricorni	5.2	3	35	34	6	28	270	0	54
	27	18 Aquarii	5.5	5	19	343	5	39	310	0	20

Satellites of Jupiter, December, 1916.

GREENWICH MEAN TIME.

Phases of the Eclipses of the Satellites for an Inverting Telescope.



Configurations at 14h 10m for an Inverting Telescope.

Day	West		East
1	·4	○	1·2· ·3
2	·4 2· ·1	○	·3
3	·2·4	○	·1 3·
4	3·	○	·4 ·2 ·1 ●
5	3· 1·2	○	· ·4
6	·3 ·2	○	·1 4·
7	1· ·3	○	·2 ·4
8		○	1· 2· ·3 4·
9	2· ·1	○	·3 4·
10	·2	○	1· ·3 4·
11	3·	○	1 4· ·2
12	○1· 3· 4·	○	2·
13	·34· 2·	○	·1
14	4· 1· ·3	○	·2 ●
15	4.	○	·1·32·
16	·4 ·12·	○	·3
17	·4 ·2	○	1· 3.
18	○3. ·4 ·1	○	·2
19	○1· 3· ·4	○	2·
20	·3 2·	○ ·4	1 ●
21	·3 1· ·	○	2 4.
22		○	·1 ·3 4·
23	1· 2·	○	·3 ·4
24	·2	○	1· ·3 ·4
25	·1	○	3· ·2 ·4
26	·3	○	1· 2· 4·
27	·3 2·	○	4· ·1 ●
28	3. 1· ·2	○	4·
29	4·	○	.1 ·2 ·3 ●
30	○2· 4· 1·	○	3·
31	4· ·2	○	1· ·3

Phenomena of Jupiter's Satellites.

[Visible at Washington.]

CENTRAL STANDARD TIME.

	h	m		
Dec. 2	12	34	I	Oc. D.
3	9	44	I	Tr. I.
	10	41	I	Sh. I.
	11	53	I	Tr. E.
	12	50	I	Sh. E.
4	4	27	III	Sh. I.
	6	10	III	Sh. E.
	7	1	I	Oc. D.
	10	10	I	Ec. R.
5	5	10	I	Sh. I.
	6	20	I	Tr. E.
	7	19	I	Sh. E.
	9	8	II	Tr. I.
	11	9	II	Sh. I.
	11	41	II	Tr. E.
	13	42	II	Sh. E.
6	4	39	I	Ec. R.
7	7	58	II	Ec. R.
10	11	33	I	Tr. I.
	12	36	I	Sh. I.
	13	42	I	Tr. E.
11	5	48	III	Tr. E.
	8	29	III	Sh. I.
	8	50	I	Oc. D.
	10	11	III	Sh. E.
	12	6	I	Ec. R.
12	6	0	I	Tr. I.
	7	5	I	Sh. I.
	8	9	I	Tr. E.
	9	14	I	Sh. E.
	11	33	II	Tr. I.
13	6	35	I	Ec. R.
14	5	46	II	Oc. D.
	10	35	II	Ec. R.
16	5	40	II	Sh. E.
18	7	40	III	Tr. I.
	9	29	III	Tr. E.
	10	40	I	Oc. D.
	12	31	III	Sh. I.
19	7	50	I	Tr. I.
	9	0	I	Sh. I.
	9	59	I	Tr. E.
	11	9	I	Sh. E.
20	5	8	I	Oc. D.
	8	31	I	Ec. R.
21	4	27	I	Tr. E.
	5	38	I	Sh. E.
	8	12	II	Oc. D.
23	5	45	II	Sh. I.
	5	50	II	Tr. E.
	8	18	II	Sh. E.
25	11	23	III	Tr. I.
26	9	41	I	Tr. I.
	10	56	I	Sh. I.
	11	51	I	Tr. E.
27	7	0	I	Oc. D.
	10	27	I	Ec. R.
28	5	25	I	Sh. I.
	6	19	I	Tr. E.
	7	33	I	Sh. E.
	10	41	II	Oc. D.
29	4	56	I	Ec. R.
	6	31	III	Ec. D
	8	14	III	Ec. R.
30	5	47	II	Tr. I.
	8	22	II	Tr. E.
	8	25	II	Sh. I.
	10	45	II	Sh. E.

Note:—I., denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation: Tr., transit of the satellite; Sh., transit of the shadow.

JUPITER—RISING.

When shadows of evening shroud hillside and plain,
And suns of the night glitter bright overhead,
Then, softly a planet is shining again,
Like satellite rising from Earth's eastern bed;

So golden and gorgeous, so placid and clear,
Grand Jupiter gleams in the light of the Sun,
When early frost comes like a blight far and near
And slowly October's leaves fall one by one.

CHARLES NEVERS HOLMES.

Newton, Mass.
41 Arlington St.

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5ʰ; Central Standard 6ʰ; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 December							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.8			19	11				
RT Sculptor.		31.5	—26	13	9.6—10.5	0	12.3	4	19;	12	11;	20	3;	27	19
UU Androm.		38.5	+30	24	10.7—11.9	1	11.7	4	4;	11	15;	19	1;	26	11
U Cephei	0	53.4	+81	20	7.0— 9.0	2	11.8	1	19;	9	7;	24	6;	31	17
Z Persei	2	33.7	+41	46	9.4—12	3	01.4	7	16;	13	19;	19	22;	26	0
TW Cassiop.		37.6	+65	19	8.2— 9.0	1	10.3	6	19;	13	23;	21	2;	28	5
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	4	9;	11	6;	18	2;	26	23
RZ Cassiop.		39.9	+69	13	6.9— 8.1	1	04.7	3	18;	10	22;	18	2;	25	6
TX Cassiop.		44.4	+62	22	9.4—10.1	2	22.2	5	17;	4	12;	23	7		
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	6	20;	14	19;	22	17;	30	16
RX Cassiop.	2	58.8	+67	11	8.6— 9.1	32	07.6					29	11		
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	5	11;	11	4;	22	16;	28	9
RT Persei		16.7	+46	12	9.5—11.5	0	20.4	1	1;	7	20;	21	11;	28	6
λ Tauri		55.1	+12	12	3.3— 4.2	3	22.9	8	10;	16	7;	24	4		
RW Tauri	3	57.8	+27	51	7.1—<11	2	18.5	7	0;	15	7;	23	15;	31	22
RV Persei	4	04.2	+33	59	9.5—11.0	1	23.4	5	0;	12	21;	20	19;	28	16
RW Persei		13.3	+42	04	8.8—11.0	15	04.8			8	0;	21	5		
SZ Tauri		31.4	+18	20	7.2— 7.7	3	03.6	3	22;	13	9;	22	19		
RS Cephei	4	48.6	+80	06	9.5—12.0	12	10.1	3	20;	16	6;	28	16		
TT Aurigae	5	02.8	+39	27	7.8— 8.7	0	16.0	6	22;	13	14;	20	6;	26	22
RY Aurigae		11.5	+38	13	10.7—11.7	2	17.5	1	1;	11	23;	22	21;	28	7
RZ Aurigae		42.9	+31	40	10.6—13.3	3	00.3	3	13;	9	14;	21	15;	27	15
SV Tauri		45.8	+28	05	9.4—11.0	2	04.0	7	16;	16	7;	24	23		
Z Orionis		50.2	+13	40	9.7—10.7	5	04.9	1	21;	12	7;	22	17		
SV Gemin.		54.6	+24	28	9.8—<11	4	00.2	4	22;	12	22;	20	22;	28	23
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	1	17;	13	4;	24	15;	30	8
U Columbae	6	11.2	—33	03	9.2—10.0	2	19.2	2	15;	13	19;	25	0;	30	15
SX Gemin.		22.0	+20	37	10.8—11.5	1	08.8	3	23;	12	3;	20	8;	28	13
RW Monoc.		29.3	+ 8	54	9.0—10.8	1	21.7	5	2;	12	17;	20	8;	27	23
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0			7	5;	19	10		
RU Monoc.	6	49.4	— 7	28	9.8—10.5	0	21.5	2	1;	9	5;	16	9;	30	17
R Can. Maj.	7	14.9	—16	12	5.8— 6.4	1	03.3	3	10;	12	12;	21	17;	30	16
RY Gemin.		21.7	+15	52	8.9—<10	9	07.2	7	10;	16	17;	26	0		
Y Camelop.		27.6	+76	17	9.5—12	3	07.3			17	3;	27	1;	36	22
TX Gemin.		30.3	+17	8	10.0—11.9	2	19.2	2	20;	11	5;	19	5;	28	0
RR Puppis		43.5	—41	08	9.4—10.7	6	10.3	3	5;	9	16;	22	12;	28	23
V Puppis	7	55.4	—48	58	4.1— 4.8	1	10.9	4	18;	12	0;	19	7;	26	13
X Carinae	8	29.1	—58	53	7.9— 8.7	0	13.0	2	6;	10	9;	18	12;	26	15
S Cancri	8	38.2	+19	24	8.2—10	9	11.6	4	19;	14	7;	23	18		
RX Hydrae	9	00.8	— 7	52	9.1—10.5	2	6.8	4	5;	13	8;	22	11;	31	14
S Velorum		29.4	—44	46	7.8— 9.3	5	22.4	5	23;	11	21;	23	18;	29	16
Y Leonis	9	31.1	+26	41	9.3—11.2	1	16.5	1	6;	9	17;	18	3;	26	13
RR Velorum	10	17.8	—41	36	10.0—10.9	1	20.5	7	18;	17	0;	26	7		
SS Carinae	10	54.2	—61	23	12.2—12.8	3	07.2	6	7;	12	22;	19	12;	26	3
ST Urs. Maj.	11	22.4	+45	44	6.7— 7.2	8	19.2	5	10;	14	5;	23	0;	13	19
RW Urs. Maj.		35.4	+52	34	10.3—11.4	7	07.9	2	13;	9	20;	17	4;	24	12
Z Draconis	11	39.8	+72	49	9.9—13.6	1	08.6	7	7;	14	1;	20	20;	27	15
RZ Centauri	12	55.6	−64	05	8.5— 8.9	1	21.0	1	10;	8	22;	16	10;	23	22
RS Can. Ven.	13	06.3	+36	28	7.5—12.5	4	19.2	1	10;	11	0;	20	14;	30	4
SS Centauri	13	07.2	—63	37	8.8—10.4	2	11.5	6	3;	13	13;	21	0;	28	10
δ Librae	14	55.6	— 8	07	4.8— 6.2	2	07.9	6	14;	13	13;	20	13;	27	12

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1916 December							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
U Coronae	15	14.1	+32	01	7.6— 8.7	3	10.9	3	8;	10	6;	24	1;	30	23
TW Draconis		32.4	+64	14	7.3— 8.9	2	19.4	7	1;	15	11;	23	21		
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	2	23;	10	15;	18	7;	25	22
SW Ophiuchi	16	11.1	— 6	44	9.2—10.0	2	10.7	3	13;	10	21;	18	5;	25	13
SX Ophiuchi		12.6	— 6	25	10.5—11.2	2	01.5	3	7;	11	13;	19	19;	28	1
R Arae		31.1	—56	48	6.8— 7.9	4	10.2	4	18;	13	14;	22	11;	31	7
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1	6	3;	17	5;	26	21		
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	4	20;	11	16;	18	11;	25	6
U Ophiuchi		11.5	+ 1	19	6.0— 6.7	0	20.1	8	23;	27	6;	23	15		
u Herculis		13.6	+33	12	4.6— 5.4	2	01.2	6	13;	12	16;	18	20;	31	3
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	4	7;	11	12;	18	17;	25	22
RV Ophiuchi		29.8	+ 7	19	9. —12	3	16.5	8	9;	15	18;	23	3;	30	12
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	5	2;	13	7;	21	11;	29	15
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	2	23;	10	11;	18	0;	25	13
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	4	6;	12	0;	19	18;	27	12
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	5	12;	13	15;	21	14;	29	14
WX Sagittae		53.6	—17	24	9.2—10.8	2	03.1	1	19;	10	7;	18	20;	27	8
WY Sagittae	17	54.9	—23	1	9.5—10.6	4	16.0	1	8;	10	16;	20	0;	29	9
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	7	23;	18	7;	28	15		
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	6	21;	14	3;	21	9;	28	15
V Serpentis		11.1	—15	34	9.5—11.1	3	10.9	7	18;	14	16;	21	14;	28	12
RZ Scuti		21.1	— 9	15	7.4— 8.3	15	03.2			15	3;			30	6
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	4	18;	13	0;	21	6;	29	13
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	2	15;	11	12;	20	10;	29	7
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	7	0;	15	7;	23	15;	31	22
RR Draconis		40.8	+62	34	9.3—13	2	19.9	7	8;	15	20;	24	8		
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	6	3;	12	18;	19	10;	26	6
β Lyrae		46.4	+33	15	3.4— 4.1	12	21.8			7	10;	20	8		
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	3	1;	12	14;	22	3		
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	1	19;	9	8;	16	22;	24	12
RV Lyrae		12.5	+32	15	11. —12.8	3	14.4	2	16;	9	22;	24	6;	31	11
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	8	6;	17	5;	26	4		
U Sagittae		14.4	+19	26	6.5— 9.0	3	09.1	6	1;	12	19;	19	13;	26	8
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	6	6;	13	15;	20	23;	28	8
TT Lyrae		24.3	+41	30	9.3—11.6	5	05.8	3	8;	8	14;	19	1;	24	7
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	2	3;	8	15;	21	16;	28	5
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	6	17;	12	17;	24	18;	30	18
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	3	10;	10	12;	16	17;	29	23
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	1	7;	10	10;	19	14;	28	17
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	6	12;	14	22;	23	8;	31	19
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	6	0;	12	19;	19	14;	26	9
UW Cygni		19.6	+42	55	10.5—10.8	3	13	7	21;	13	23;	20	20;	27	18
V Vulpec.		32.3	+26	15	8.2—9.8	37	19.0			12	18				
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	3	22;	13	13;	23	4		
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	2	13;	11	18;	20	22;	30	3
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	3	7;	10	9;	18	7;	25	18
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	4	0;	9	20;	21	13;	27	9
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	8	12;	18	14;	28	16		
VV Cygni	21	02.3	+45	23	12.1—13.8	1	11.4	1	13;	8	22;	23	16;	31	2
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	1	18;	11	10;	21	3;	30	19
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	5	22;	13	19;	21	16;	29	13
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3			23	23				
RT Lacertae	21	57.4	+43	24	9.1—10.5	5	01.7	1	21;	12	1;	22	4		
RW Lacertae	22	40.6	+49	08	10.2—11.2	5	04.4	5	4;	10	8;	20	17;	25	22
X Lacertae	22	45.0	+55	54	8.2— 8.6	5	10.6	2	18;	13	16;	24	13;	30	0
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.3	7	14;	15	21;	24	4		
Y Piscium		29.3	+ 7	22	9.0—12.0	3	18.4	8	4;	15	17;	23	5;	30	18
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	3	10;	11	15;	19	21;	28	3

Maxima of Variable Stars of Short Period.

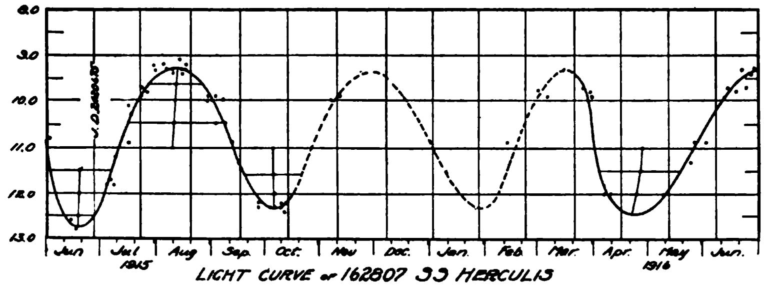
[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. December							
	h	m	°	'		d	h	d	h	d	h	d	h	d	h
SX Cassiop.	0	05.5	+54	20	8.6— 9.4	36	13.7	5	3						
SY Cassiop.	0	09.8	+57	52	9.3— 9.9	4	1.7	2	2;	10	5;	18	9;	26	10
RR Ceti	1	27.0	+0	50	8.3— 9.0	0	13.3	3	4;	10	22;	18	16;	26	10
RW Cassiop.	1	30.7	+57	15	8.9—11.0	14	19.2	8	12;	23	7				
V Arietis	2	09.6	+11	46	8.3— 9.0	0	23.8	4	21;	12	20;	20	18;	28	17
SU Cassiop.	2	43.0	+68	28	6.5— 7.0	1	22.8	6	19;	14	14;	22	9;	30	4
TU Persei	3	01.8	+52	49	11.4—12.2	0	14.6	2	23;	10	6;	17	12;	24	19
RW Camelop.	3	46.2	+58	21	8.2— 9.4	16	00.0	3				19			
SX Persei	4	10.2	+41	27	10.4—11.2	4	07.0	2	8;	10	22;	19	12;	28	2
SV Persei		42.8	+42	07	8.8— 9.6	11	03.1	4	19;	15	22;	27	1		
RX Aurigae	4	54.5	+39	49	7.2— 8.1	11	15.0			12	12;			24	3
SX Aurigae	5	04.6	+42	02	8.0— 8.7	1	12.8	2	0;	9	16:	17	8;	24	23
SY Aurigae		05.5	+42	41	8.4— 9.5	10	03.3			11	1;	21	4;	31	7
Y Aurigae		21.5	+42	21	8.6— 9.6	3	20.6	3	10;	11	3;	18	21;	26	14
RZ Gemin.	5	56.6	+22	15	9.1—10.0	5	12.7	6	5;	11	18;	22	19;	28	8
RS Orionis	6	16.5	+14	44	8.2— 8.9	7	13.6	4	21;	12	11;	20	0;	27	14
T Monoc.		19.8	+7	08	5.7— 6.8	27	00.3					23	21		
RZ Camelop.		23.7	+67	06	11.0—13.0	0	11.5	6	7;	13	12;	20	17;	27	22
W Gemin.		29.2	+15	24	6.7— 7.5	7	22.0	8	3;	16	1;	23	23;	31	21
ζ Gemin.	6	58.2	+20	43	3.7— 4.3	10	03.7	2	14;	12	17;	22	21		
RU Camelop.	7	10.9	+69	51	8.5— 9.8	12	06.5	7	11			29	18		
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	3	9;	11	8;	19	6;	27	5
V Carinae	8	26.7	−59	47	7.4— 8.1	6	16.7	1	16;	8	9;	21	18;	28	11
T Velorum	8	34.4	−47	01	7.6— 8.5	4	15.3	4	5;	13	11;	22	18		
V Velorum	9	19.2	−55	32	7.5— 8.2	4	08.9	4	2;	12	20;	21	14;	30	8
RR Leonis	10	02.1	+24	29	9.1—10.1	0	10.9	5	6;	12	1;	18	20;	25	14
SU Draconis	11	32.2	+67	53	8.9— 9.6	0	15.8	4	21;	11	12;	18	2;	24	17
S Muscae	12	07.4	−69	36	6.4— 7.3	9	15.8	2	0;	11	16;	21	8;	30	23
SW Draconis		12.8	+70	04	8.8— 9.6	0	13.7	6	23;	14	22;	22	21;	30	21
T Crucis		15.9	−61	44	6.8— 7.6	6	17.6	3	18;	10	12;	23	22;	30	16
R Crucis		18.1	−61	04	6.8— 7.9	5	19.8	3	18;	9	13;	21	5;	27	1
S Crucis	12	48.4	−57	53	6.5— 7.6	4	16.6	5	12;	10	5;	19	14;	28	23
W Virginis	13	20.9	−2	52	8.7—10.4	17	06.5	7	15;			24	21		
SS Hydrae		25.0	−23	08	7.4— 8.1	8	4.8	2	0;	14	5;	18	10;	26	14
RV Urs. Maj.	13	29.4	+54	31	9.2— 9.9	0	11.2	5	9;	12	9;	19	10;	26	10
ST Virginis	14	22.5	−0	27	10.3—11.4	0	09.9	7	21;	16	3;	24	6		
V Centauri		25.4	−56	27	6.4— 7.8	5	11.9	2	17;	8	5;	19	5;	30	4
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	3	7;	10	20;	18	9;	25	22
RU Bootis	14	41.5	+23	44	12.8—14.3	0	11.9	3	15;	11	1;	18	11;	25	21
R Triang. Austr.	15	10.8	−66	08	6.7— 7.4	3	09.3	5	18;	12	13;	19	9;	26	4
S Triang. Austr.	15	52.2	−63	29	6.4— 7.4	6	07.8	3	2;	9	10;	15	17;	28	9
S Normae	16	10.6	−57	39	6.6— 7.6	9	18.1	4	19;	14	13;	24	7		
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	9	16;	18	13;	29	10		
RV Scorpii	16	51.8	−33	27	6.7— 7.4	6	01.5	5	10;	11	12;	23	15;	29	16
X Sagittarii	17	41.3	−27	48	4.4— 5.0	7	00.3	6	9;	13	9;	20	9;	27	10
Y Ophiuchi		47.3	−6	07	6.1— 6.5	17	02.9			11	12;	28	14		
W Sagittarii	17	58.6	−29	35	4.3— 5.1	7	14.3	7	14;	15	5;	22	19;	30	9
Y Sagittarii	18	15.5	−18	54	5.4— 6.2	5	18.6	4	7;	10	2;	21	15;	27	9
U Sagittarii		26.0	−19	12	6.5— 7.3	6	17.9	2	22;	9	16;	23	4;	29	22

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. December							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
Y Scuti	18	32.6	− 8	27	8.7— 9.2	10	08.3	3	1;	13	9;	23	18		
Y Lyrae		34.2	+43	52	11.3—12.3	0	12.1	3	10;	9	10;	21	12;	27	18
RZ Lyrae		39.9	+32	42	9.9—11.2	0	12.3	7	0;	13	3;	25	9;	31	13
RT Scuti		44.1	−10	30	9.1— 9.7	0	11.9	4	13;	10	11;	22	9;	28	8
κ Pavonis	18	46.6	—67	22	3.8— 5.2	9	02.2	4	13;	13	15;	22	18;	31	20
U Aquilae	19	24.0	− 7	15	6.2— 6.9	7	00.6	6	20;	13	21;	20	22;	27	22
XZ Cygni		30.4	+56	10	8.6— 9.3	0	11.2	6	4;	13	4;	20	4;	27	4
U Vulpec.		32.2	+20	07	6.5— 7.6	7	23.5	8	18;	16	17;	24	17		
SU Cygni		40.8	+29	01	6.2— 7.0	3	20.3	3	20;	11	13;	19	5;	26	22
η Aquilae		47.4	+ 0	45	3.7— 4.5	7	04.2	1	20;	9	0;	23	9;	30	13
S Sagittae		51.5	+16	22	5.6— 6.4	8	09.2	8	3;	16	12;	24	22		
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	6	22;	13	6;	19	14;	25	21
X Cygni	20	39.5	+35	14	6.0— 7.0	16	09.3	3	16			20	2		
T Vulpec.		47.2	+27	52	5.5— 6.1	4	10.5	1	14;	10	11;	19	8;	28	5
WY Cygni		52.3	+30	03	9.6—10.4	0	13.5	4	1;	10	18;	24	5;	30	23
RV Capric.		55.9	−15	37	9.2—10.1	0	10.7	3	4;	9	22;	16	15;	30	1
TX Cygni	20	56.4	+42	12	8.5— 9.7	14	17.4			12	9;	27	3		
VY Cygni	21	00.4	+39	34	8.8− 9.5	7	20.6	6	9;	14	6;	22	3;	29	23
SW Aquarii		10.2	— 0	20	9.9—10.8	0	11.0	4	2;	11	0;	24	18;	31	16
VZ Cygni	21	47.7	+42	40	8.2− 9.2	4	20.7	2	18;	12	11;	22	5;	31	23
Y Lacertae	22	05.2	+50	33	9.1− 9.6	4	07.8	7	20;	16	12;	25	3		
δ Cephei		25.5	+57	54	3.7− 4.6	5	08.8	2	9;	13	3;	23	20;	29	5
Z Lacertae		36.9	+56	18	8.2− 9.0	10	21.1	8	8;	19	5;	30	2		
RR Lacertae		37.5	+55	55	8.5− 9.2	6	10.1	2	12;	8	22;	21	19;	28	5
V Lacertae	22	44.5	+55	48	8.5— 9.5	4	23.6	3	0;	8	0;	17	23;	27	22
SW Cassiop.	23	03.7	+58	11	9.2− 9.7	5	10.6	5	18;	10	5;	22	2;	27	12
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	7	3;	13	10;	19	17;	26	0
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4	5	21;	18	1;	30	4		
V Cephei	23	51.7	+82	38	6.0—7.0	0	23.6	2	23;	12	21;	22	21;	27	20

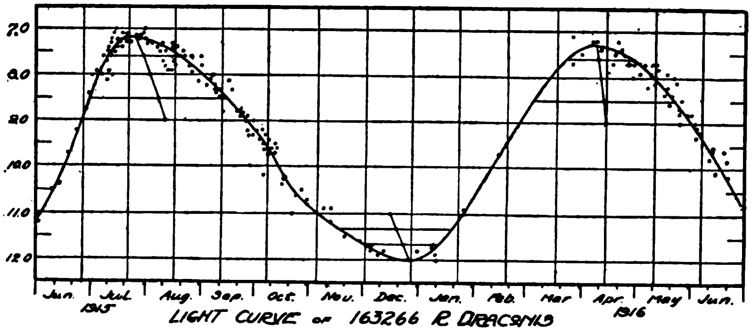


LIGHT CURVE OF 162807 33 HERCULIS

Maxima
- Aug. 12, 1915 (J.D. 2420722); Mag. 9.3.
- Nov. 30, 1915 (about)
- Mar. 15, 1916 "
- Jul 3, 1916 "

Minima
- Jun 17, 1915, (J.D. 2420649); Mag. 12.7
- Oct. 5, 1915, (J.D. 2420776); Mag. 12.3
- Jan. 28, 1916, (about)
- Apr. 20, 1916, "

C B Lindsley
Cinti, O.

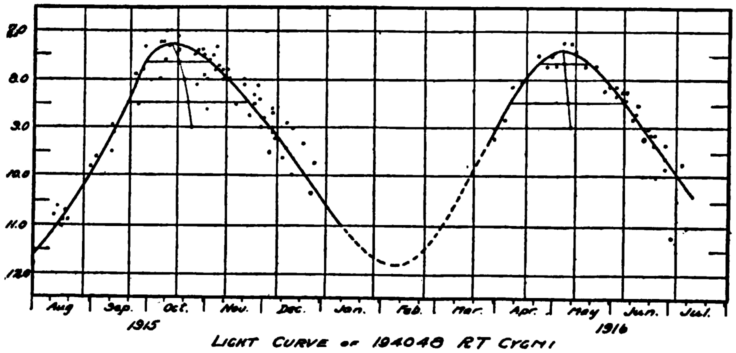


LIGHT CURVE OF 163266 R DRACONIS

Max. Jul. 25, 1915 (J.D. 2420704); min. Dec. 20, 1915 (J.D. 2420852), mag. 12; max. Apr. 7, 1916, (J.D. 2420961), mag. 7.3

Observations by Amer. Assn. of Var. Star Observers.

Chas. B. Lindsley
Cinti., O.

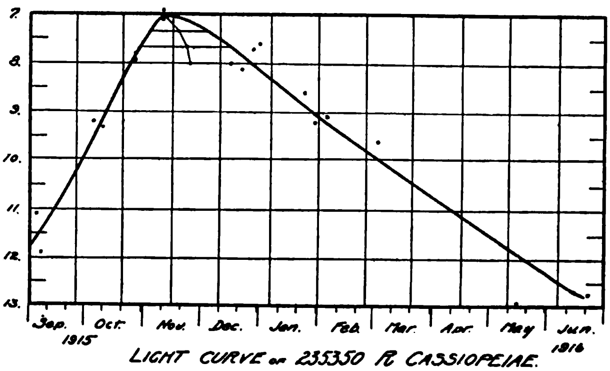


LIGHT CURVE OF 194048 RT CYGNI

Max. Oct. 13, 1915 (J.D. 2420784); mag. 7.3. Max. May 4, 1916, (J.D. 2420988); mag. 7.4.

Observations by Amer. Assn. of Var. Star Observers

Chas. B. Lindsley
Cinti., O.



LIGHT CURVE OF 235350 R CASSIOPEIAE.

Max. Nov. 12, 1916 (J.D. 2420814); mag. 7.0

Obs. by Amer. Assn. of Var. Star Observers.

Chas. B. Lindsley
Cinti., O.

COMET AND ASTEROID NOTES.

Ephemeris of Comet *b* 1916 (Wolf).—The following ephemeris is taken from the *Lick Observatory Bulletin*, No. 286, and was computed by Professor R. T. Crawford of the Berkeley Astronomical Department. It will be remembered that this comet was discovered when far out in its orbit, near the path of Jupiter, and that the elements derived from the observations in April and May indicated that it would not reach perihelion until June 1917. The last available observation, that of Barnard on July 5, was represented by the elements within the errors $+0^s.3$ and $-1''$, in right ascension and declination respectively.

After having passed conjunction with the sun the comet will be in position for observation in December of this year. From then on until next May its position will become more favorable and the comet will continually increase in brightness.

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1916 G.M.T.		True α	True δ	log Δ	Br.
		h m s	° ′ ″		
Nov.	29.5	15 06 47.9	—5 07 13	0.5862	2.96
	30.5	08 25.9	10 18		
Dec.	1.5	10 04.4	13 19	0.5829	3.04
	2.5	11 43.3	16 16		
	3.5	13 22.6	19 08	0.5794	3.13
	4.5	15 02.4	21 56		
	5.5	16 42.6	24 40	0.5760	3.22
	6.5	18 23.2	27 20		
	7.5	20 04.3	29 55	0.5724	3.32
	8.5	21 45.8	32 25		
	9.5	23 27.8	34 51	0.5687	3.42
	19.5	25 10.2	37 11		
	11.5	26 53.1	39 27	0.5650	3.52
	12.5	28 36.4	41 38		
	13.5	30 20.2	43 43	0.5612	3.63
	14.5	32 04.4	45 43		
	15.5	33 49.0	47 38	0.5574	3.74
	16.5	35 34.1	49 27		
	17.5	37 19.7	51 11	0.5534	3.86
	18.5	39 05.7	52 49		
	10.5	40 52.2	54 22	0.5494	3.98
	20.5	42 39.1	55 49		
	21.5	44 26.5	57 10	0.5453	4.11
	22.5	46 14.3	58 25		
	23.5	48 02.5	—5 59 33	0.5411	4.25
	24.5	49 51.2	—6 00 35		
	25.5	51 40.3	01 31	0.5369	4.39
	26.5	53 29.9	02 21		
	27.5	55 19.9	03 04	0.5326	4.54
	28.5	57 10.3	03 40		
	29.5	15 59 01.2	04 10	0.5282	4.70
	30.5	16 00 52.5	04 33		
Dec.	31.5	16 02 44.3	—6 04 49	0.5237	4.86

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, September-October, 1916.

This month's report is in many respects the most excellent the Association has submitted, and a fitting close for our fiscal year. During the past month 232 variable stars were observed, which breaks our monthly record, which heretofore has been 196 variables.

The weather was remarkably fine during September and exceptionally meritorious lists were contributed by Messrs. Bancroft, Bouton, Burbeck, and McAteer.

We welcome as a new member of the Association this month Mr. C. R. Rogers, "Ro" of Minneapolis, Minn.

Lists of observations were received from Messrs. de Perrot, Lacchini, and Yendell, too late for publication in last month's report and are included herewith.

A most enjoyable event for those participating was a week-end spent at the home of Mr. J. J. Crane, in Sandwich, Mass. Mr. Campbell, Mr. Burbeck and the Secretary had this pleasure, and two fine nights were spent to good advantage in Mr. Crane's well equipped observatory.

The feature of chief interest and importance in this report is the observed anomalous maximum of the Variable 213843 SS Cygni. The average interval between the last three maxima has been thirty-five days, much shorter than is usual. The rise was observed by many of our members. On one night ten observers had it under inspection, and on September 30 a drop of .5 of a magnitude in one hour was observed, which is extraordinary even in the case of this erratic and enigmatic star.

The following calculated dates of maxima are cited from the "Companion to the Observatory."

Nov. 4	012502	R Piscium	Nov. 26	013133	R Trianguli
15	190108	R Aquilae	28	*204405*	T Aquarii

Mr. Bancroft calls attention to an error in Klein's Star Atlas, the position of the Variable 045307 R Orionis being incorrectly indicated.

The following members of the Association were honored with an election to membership in the American Astronomical Society at the recent meeting at Swarthmore, Pa.: Messrs. Bancroft, Burbeck, Gray, Lindsley, and D. B. Pickering.

A meeting of our Association will be held in Cambridge, Mass., Saturday November 18. Professor E. C. Pickering, Director of the Harvard College Observatory, has graciously offered to entertain us on that occasion. This is an exceptional opportunity for our members to meet together in the happy fellowship of kindred spirits that insures a red-letter occasion, and it is hoped that we will have a large attendance. A special appeal is made to distant members to attend this meeting. Members who expect to be present at the meeting are requested to notify the Secretary fully two weeks in advance of the date of the meeting.

The annual report of the Association is included in this report and contains the individual records for the year. A record of nearly 60000 observations in five years work well attests the value of coöperation, and is a highly creditable result.

During the past year we have maintained a membership of thirty observers, greatly increased the scope of our work, and beyond question the quality of the observations is approaching a state of excellence that will soon render them authoritative.

VARIABLE STAR OBSERVATIONS September-October, 1916.

001032
S Sculptoris

J.D.	Est.	Obs.
242		
1134.7	11.4	Ba

001046
X Androm.

1113.6	<12.0	Bu
26.6	13.6	B
26.6	<13.2	Ba

001726
T Androm.

1109.6	9.5	O
10.7	9.4	Ly
11.6	9.5	M
15.7	9.8	Ly
26.6	11.1	Ba
27.6	11.2	Bu
28.7	10.9±	V
32.6	11.3	Pi
32.6	<10.7	S
33.6	11.5	Bu

001755
T Cassiop.

1109.6	9.8	M
11.5	9.2	O
16.6	9.1	B
21.5	9.4	O
26.6	9.2	Ba
27.6	9.8	Bu
28.6	9.4	Pi
32.5	10.5	O
32.6	10.0	S

001838
R Androm.

1066.4	7.3	Pe
67.4	7.5	Pe
70.4	7.6	Pe
74.4	7.7	Pe
75.4	7.7	Pe
76.4	7.8	Pe
77.4	7.8	Pe
80.4	7.9	Pe
81.4	7.9	Pe
96.4	8.4	Pe
97.4	8.5	Pe
1110.6	9.2	Cr
11.5	8.8	O
11.6	9.1	M
13	9.1	T
13.6	9.1	Cr
14	9.1	T
18.6	8.9	B
26.6	9.1	Ba
27.6	9.8	Bu
28.5	9.2	O
28.7	9.3	V
31	9.1	T
32.6	9.5	Pi
33.6	9.7	Hu
35.5	10.0	O
39.5	10.3	O

001909
S Ceti

J.D.	Est.	Obs.
242		
1116.7	9.3	M
26.6	9.0	Ba
32.7	8.5	Pi
33.7	9.1	Ba
37.6	8.5	M
37.6	8.4	S

003179
Y Cephei

1125.6	11.0	Hu
26.6	11.0	Ba
33.7	12.4	Bu

004047
U Cassiop.

1077.4	10.1	L
98.4	9.9	L
1111.6	10.5	B
14.6	10.6	M
22.6	10.7	M
26.6	10.9	Ba
27.7	10.6	Bu
32.6	<9.9	S
33.7	10.8	Bu
35.5	10.0	Wh

004132
RW Androm.

1111.6	7.8	M
16.6	7.5	O
16.6	7.6	Cr
16.6	7.6	Bu
20.6	8.0	B
26.6	8.1	Ba
27.6	8.1	Bu
28.5	8:1	O
32.5	8.2	O
32.6	8.1	Pi
33.7	8.3	Bu
35.5	8.2	O
39.5	8.6	O
42.5	8.7	O

004435
V Androm.

1109.6	9.3	Bu
10.7	9.2	Ly
12.6	9.7	M
15.7	9.2	Ly
16.6	9.6	O
16.6	9.5	Cr
20.6	9.3	B
22.7	9.3	Ly
26.6	9.7	Ba
28.5	9.8	O
32.5	10.0	O
32.6	10.3	Hu
32.6	10.1	Pi
33.7	9.0	Bu
35.5	10.2	O
39.5	10.4	O

004533
RR Androm.

J.D.	Est.	Obs.
242		
1109.5	9.2	Nt
11.6	9.5	M
16.6	9.2	O
16.6	9.4	Cr
16.6	9.2	Bu
24.6	9.4	Cr
26.6	9.0	Ba
28.5	9.4	O
32.5	9.4	O
33.6	9.2	Hu
33.7	8.8	Bu
35.5	9.5	O
39.5	9.4	O
42.5	9.6	O

004746
RV Cassiop.

1098.4	9.6	L
1122.6	10.2	M
26.6	9.6	Ba
33.5	10.6	O
33.7	10.2	Bu
35.5	10.6	Wh
39.5	10.7	O

004958
W Cassiop.

1098.4	9.4	L
1109.6	9.3	M
16.6	8.5	B
26.6	9.0	Ba
32.5	9.7	O
33.7	10.2	Bu
37.5	10.0	O

010102
Z Ceti

1126.6	9.0	Ba

010940
U Androm.

1126.6	12.1	Ba
32.5	11.9	Pi
33.7	<12.6	Bu

011208
S Piscium

1109.7	<12.4	Bu
26.6	13.0	Ba

011272
S Cassiop.

1118.6	11.4	Bu
26.6	10.0	Ba
27.6	9.7	B
33.6	9.8	M
33.7	11.0	Bu
37.5	9.4	O
39.5	9.5	O

011712
U Piscium

J.D.	Est.	Obs.
242		
1126.6	<13.0	Ba

012350
RZ Persei

1109.7	10.7	Bu
1116.7	<11.0	M
26.6	12.0	Ba

012502
R Piscium

1109.7	10.8	Bu
26.6	8.9	Ba
37.6	8.0	S

013238
RU Androm.

1109.7	<12.1	Bu
26.6	<13.0	Ba
32.5	<12.1	Pi

013338
Y Androm.

1109.7	<12.4	Bu
26.6	<13.0	Ba
32.5	<13.0	Ba

014958
X Cassiop.

1109.6	12.0	Nt
09.6	11.8	M
09.7	11.5	Bu
26.6	12.0	Ba

015354
U Persei

1109.7	8.4	Bu
1116.6	8.5	B
16.7	8.5	M
26.6	8.1	Ba
28.7	8.1	V
35.6	8.0	Pi
35.6	7.2	Wpi

015912
S Arietis

1109.7	<12.5	Bu
1126.7	<13.8	Ba
32.6	<13.8	B

021024
R Arietis

1098.4	8.8	Pe
1106.7	8.5	Pi
09.7	8.2	Bu
26.7	7.5	Ba
32.6	8.5	M
34.6	8.0	Pi
37.6	8.0	S

021143
W Androm.

1126.7	12.7	Ba

021403
o Ceti

J.D.	Est.	Obs.
242		
1081.6	8.5	L
83.6	8.6	L
1102.6	8.4	L
06.7	8.2	Pi
16.6	7.6	Bu
16.6	7.7	Cr
16.6	7.5	O
16.7	7.8	M
26.7	6.9	Ba
27.7	7.4	Bu
31.8	7.1	Mu
32	7.5	T
32.7	7.0	Pi
34.8	6.8	Mu
37.7	6.5	M

021558
S Persei

1116.6	9.3	B
16.7	9.7	M
26.7	9.3	Ba

022000
R Ceti

1126.7	12.0	Ba

022813
U Ceti

1126.7	12.0	Ba
32.7	11.8	Pi
37.7	<11.0	M

023133
R Triang.

1126.7	10.5	Ba
27	9.9	T
27.7	9.9	B
28	9.9	T
31	10.3	T
32	10.0	T
35	9.9	T
37	10.0	T

024356
W Persei

1077.4	9.0	L
98.4	9.2	L
1110.7	9.0	Ly
16.7	9.1	M
23.6	8.9	Ba
26.7	9.0	Ba
30.7	9.6	Pi
35.6	9.6	Pi
35.6	9.4	Wpi

030514
U Arietis

1126.7	<13.1	Ba

031401
X Ceti

1132.7	10.0	Pi
32.7	10.2	Ba

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J.D.	Est.	Obs.
032043		
Y Persei		
242		
1109.4	10.0	L
16.7	10.1	M
26.7	9.8	B
26.7	9.9	Ba
30.7	10.2	Pi
032335		
R Persei		
1126.7	<12.5	Sp
30.7	<11.1	Pi
033362		
U Camelop.		
1126.7	7.2	Ba
33.7	8.4	M
035124		
T Eridani		
1132.8	8.1	Ba
035915		
V Eridani		
1132.7	9.1	Ba
041619		
T Tauri		
1131.9	10.2	M
042209		
R Tauri		
1131.9	<10.8	M
32.7	<12.9	Ba
32.8	<11.5	Pi
042215		
W Tauri		
1081.6	<11.4	L
1100.6	<11.4	L
26.7	11.0	Ba
30.7	10.9	Pi
31.9	10.7	M
042309		
S Tauri		
1131.9	<10.8	M
32.7	<12.9	Ba
32.8	11.5	Pi
043065		
T Camelop.		
1126.7	11.9	Ba
33.7	12.2	M
043208		
RX Tauri		
1132.7	<12.1	Ba
32.8	12.3	Pi
043274		
X Camelop.		
1077.4	8.1	L
83.6	7.9	L
98.4	8.1	L

J.D.	Est.	Obs.
X Camelop.		
242		
1106.7	8.3	Pi
09.6	8.2	O
09.6	8.5	Cr
10.6	8.4	O
10.6	8.3	Cr
16.6	9.0	O
16.6	8.9	Cr
16.6	9.1	Bu
17.6	8.9	O
17.6	9.1	Cr
17.6	9.1	Bu
20.5	9.0	O
20.6	9.0	Ba
21.5	9.5	O
23.6	10.2	Nt
23.6	10.2	Cr
26.7	10.3	Ba
27.6	10.1	B
27.6	10.4	Cr
28.5	10.8	O
29.5	10.8	O
29.6	9.5	Bu
32.5	11.1	O
33.7	11.2	M
37.6	11.4	B
044617		
V Tauri		
1132.8	<11.5	Pi
33.7	12.2	Ba
045307		
R Orionis		
1134.7	12.5	Ba
045514		
R Leporis		
1100.6	7.3	L
15.6	7.0	L
16.8	7.8	M
32.8	6.9	Ba
050003		
V Orionis		
1132.7	9.1	Ba
32.9	9.7	M
050022		
T Leporis		
1132.8	<11.4	Ba
050953		
R Aurigae		
1123.8	8.7	M
26.7	8.7	Ba
32.7	8.7	Pi
052036		
W Aurigae		
1116.8	9.3	M
26.7	<12.2	Ba
32.7	<12.5	Ba
32.8	8.5	Pi

J.D.	Est.	Obs.
052034		
S Aurigae		
242		
1081.6	9.1	L
1116.8	8.8	M
26.7	8.3	Ba
052405		
S Orionis		
1116.8	11.1	M
32.8	10.2	Ba
053005		
T Orionis		
1100.6	10.0	L
15.6	9.5	L
16.8	10.0	M
053006		
S Camelop.		
1133.7	8.5	M
053531		
U Aurigae		
1123.9	9.5	M
32.7	9.5	Ba
054319		
SU Tauri		
1132.7	9.5	Ba
34.6	9.8	Ba
054920		
U Orionis		
1081.6	7.4	L
31.9	8.9	M
32.7	8.8	Ba
054974		
V Camelop.		
1120.6	<12.8	Ba
26.7	<12.8	Ba
33.7	<11.3	M
37.7	13.3	B
055353		
Z Aurigae		
1116.8	10.7	M
32.7	10.6	Ba
060450		
X Aurigae		
1081.6	<11.9	L
1100.6	<11.4	L
16.8	<11.1	M
32.7	10.0	Ba
060547		
SS Aurigae		
1081.6	<11.6	L
83.6	<12.4	L
1100.6	<11.6	L
02.6	<11.6	L
15.6	<11.6	L
16.8	10.9	M
23.8	10.6	M

J.D.	Est.	Obs.
SS Aurigae		
242		
32.7	<13.0	Ba
32.8	<12.4	Pi
34.7	<13.3	Ba
061647		
V Aurigae		
1116.8	11.2	M
32.7	10.4	Ba
061702		
V Monoc.		
1132.8	9.9	Ba
063159		
U Lyncis		
1132.7	11.2	Ba
063558		
S Lyncis		
1132.7	10.0	Ba
064030		
X Gemin.		
1132.7	11.5	Ba
065111		
Y Monoc.		
1132.8	11.7	Ba
065208		
X Monoc.		
1132.8	7.2	Ba
065355		
R Lyncis		
1132.7	<12.5	Ba
065820		
TW Gemin.		
1123.9	8.3	M
32.7	8.5	Ba
070122a		
R Gemin.		
1123.9	8.5	M
32.7	8.3	Ba
32.8	8.2	Pi
070122b		
Z Gemin.		
1123.9	<11.5	M
32.7	12.6	Ba
070310		
R Can. Min.		
1115.6	8.6	L
32.8	8.0	Ba
071713		
V Gemin.		
1132.8	<12.8	Ba

J.D.	Est.	Obs.
072708		
S Can. Min.		
242		
1123.9	8.7	M
32.8	8.6	Ba
072811		
T Can. Min.		
1123.9	10.3	M
32.8	10.2	Ba
073508		
U Can. Min		
1110.7	<11.6	Ly
15.6	<12.4	L
32.8	12.0	Ba
073723		
S Gemin.		
1132.8	13.0	Ba
074323		
T Gemin.		
1123.9	9.0	M
32.8	9.7	Pi
32.8	9.5	Ba
074922		
U Gemin.		
1102.6	<10.0	L
32.8	<12.3	Pi
32.8	<13.3	Ba
083350		
X Urs. Maj.		
1132.8	12.5	Ba
090151		
V Urs. Maj.		
1081.3	10.1	L
1100.6	10.2	L
15.6	10.3	L
32.8	10.3	Ba
103769		
R Urs. Maj.		
1110.5	10.3	Ba
10.7	10.1	Ly
12.6	9.7	M
15.7	9.6	Ly
17.6	8.9	O
17.6	8.8	Bu
20.5	8.5	Ba
21.6	8.8	B
22.8	8.9	Ly
23.5	8.3	Ba
23.6	8.2	M
24.6	8.1	M
25.7	8.5	Ly
26.5	8.0	Ba
27.6	7.9	M
32.5	7.9	Ba
33.6	7.7	M
36.6	7.5	M

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123160
T Urs. Maj.

J. D.	Est.	Obs.
242		
1060.4	8.8	Pe
62.4	8.9	Pe
65.4	8.9	Pe
66.4	9.0	Pe
67.4	9.0	Pe
71.4	9.2	Pe
74.4	9.2	Pe
75.4	9.3	Pe
76.4	9.3	Pe
79.4	9.6	Pe
96.4	10.5	Pe
98.4	10.9	Pe
1110.6	<10.8	Pi
10.7	11.3	Ly
15.7	11.9	Ly
20.5	11.8	Ba
22.8	<12.0	Ly
23.6	12.0	B
26.5	12.2	Ba
27.6	11.7	Nt
32.5	11.1	Wh
37.6	<10.8	M
37.6	<10.0	Bu

123307
R Virginis

1067.4	9.5	L

123459
RS Urs. Maj.

1110.6	8.7	Pi
10.6	8.7	Wpi
13.6	9.1	M
20.5	8.7	Ba
25.6	8.5	M
26.5	9.0	Ba
29.6	8.6	M
32.5	9.2	Ba
33.6	9.3	M
34.5	9.8	Wh
37.6	9.8	M

123961
S Urs. Maj.

J. D.	Est.	Obs.
1081.4	8.6	L
98.4	8.5	L
1109.6	8.0	M
10.5	8.0	O
10.6	8.1	Pi
10.6	8.5	Wpi
10.7	7.9	Ly
13.6	7.6	M
15.3	8.0	L
17.6	8.0	O
18.6	7.8	B
20.5	8.0	O
20.5	7.6	Ba
21.5	7.9	Cr
21.6	7.8	Bu
22.8	8.1	Ly
242		
25.7	8.1	Ly
26.5	8.0	Ba
27.6	8.2	M
27.6	8.1	Nt
29.5	8.1	O
32.5	8.1	O
32.5	8.3	Wh
32.5	7.8	Ba
33.6	8.3	M
34.7	8.2	Ly
37.6	8.3	M
37.6	7.9	Cr

133273
T Urs. Min.

1113.6	10.8	Bu
20.5	11.4	Ba
26.5	11.6	Ba
27.6	11.5	M
32.5	11.7	Ba

134440
R Can. Ven.

1096.4	10.2	L
1105.4	10.2	L
10.5	9.8	Ba
13.6	9.5	Bu
18.6	9.3	B
20.5	9.4	Ba
26.5	9.0	Ba
31.6	8.7	M
32.5	8.9	Ba

140113
Z Bootis

1113.5	<11.9	Bu

141567
U Urs. Min.

1113.6	9.0	Bu
20.5	9.0	Ba
20.6	8.9	B
23.6	9.1	Pi
26.5	8.6	Ba
27.6	8.8	M
27.6	8.8	S
32.5	8.7	Ba

141954
S Bootis

1110.5	10.4	Ba
10.6	10.8	Pi
10.6	10.2	Wpi
13.6	10.7	M
13.6	9.8	Bu
18.6	11.0	B
20.5	11.3	Ba
26.5	11.5	Ba
26.5	<11.0	Wh
32.5	12.0	Ba

142539
V Bootis

J.D.	Est.	Obs.
242		
1075.4	7.3	L
79.4	7.5	L
91.4	7.7	L
1105.4	8.0	L
08.7	8.0	Mu
09.4	8.0	L
10.5	7.7	Ba
10.5	8.0	O
10.6	8.0	Pi
10.6	7.7	Wpi
11.6	8.0	M
13.5	8.1	Bu
18.6	7.9	B
20.5	8.5	O
20.5	8.1	Ba
26.5	8.2	Ba
26.6	8.6	Wh
32.5	8.8	O
32.5	8.3	Ba
32.6	9.0	S

142584
R Camelop.

1098.4	11.7	L
1110.5	12.1	Ba
10.7	11.7	Ly
13.6	12.3	Bu
18.6	<12.2	B
22.8	<12.0	Ly
32.7	<11.3	Wh

143227
R Bootis

1061.4	7.8	Pe
71.4	7.5	Pe
74.4	8.2	Pe
75.4	8.1	Pe
76.4	8.2	Pe
79.4	8.6	Pe
96.4	9.0	L
1109.4	10.0	L
10.5	10.0	Ba
10.6	10.1	Pi
10.6	10.1	Wpi
11.6	8.1	M
13.5	10.2	Bu
20.5	10.9	Ba
26.5	11.3	Wh
26.5	11.4	Ba
32.5	11.7	Ba

144918
U Bootis

1109.6	10.9	B
13.5	<10.7	Bu
14.6	10.2	M
24.5	10.5	Ba

150605
Y Librae

J.D.	Est.	Obs.
242		
1067.4	<12.0	L
79.4	<12.0	L
98.3	<12.0	L

151520
S Librae

1067.4	9.5	L
79.4	9.3	L
98.3	9.5	L

151714
S Serpentis

1113.6	8.4	Bu
20.5	8.7	Ba
22.6	9.2	V
26.5	9.0	Ba
29.6	9.4	M
32.5	9.3	Ba

151731
S Cor. Bor.

1074.4	11.8	Pe
75.4	11.8	Pe
76.4	11.8	Pe
1113.6	<11.2	Bu
23.6	13.0	B
24.5	<12.7	Ba
24.6	10.6	Hu

151822
RS Librae

1067.4	<11.2	L
79.4	<10.6	L

152714
RU Librae

1067.4	10.7	L
79.4	11.4	L
96.3	11.6	L

153378
S Urs. Min.

1083.6	9.9	L
1110.7	10.4	Ly
13.6	10.3	Bu
14.6	10.0	M
18.6	10.0	B
20.5	10.3	Ba
22.8	10.7	Ly
23.6	10.8	Pi
26.5	10.3	Ba
32.6	10.4	Ba
34.7	10.8	Ly

154428
R Cor. Bor.

J.D.	Est.	Obs.
1063.4	6.0	L
64.4	6.3	Pe
65.4	6.2	Pe
66.4	6.0	L
67.4	6.2	Pe
242		
67.4	5.9	L
70.4	6.2	Pe
71.4	6.2	Pe
71.4	6.0	L
74.4	6.2	Pe
75.4	6.1	Pe
76.4	6.1	Pe
77.4	6.0	Pe
77.4	5.9	L
77.4	6.1	Pe
79.4	6.0	L
81.4	6.0	L
83.4	6.0	L
87.3	6.0	L
89.3	6.0	L
95.3	5.8	L
96.4	6.1	Pe
98.4	6.0	L
1106.6	6.0	Pi
08.7	6.0	Mu
09.3	5.9	L
09.6	6.3	Gr
09.6	5.9	Bu
09.6	6.0	Cr
09.6	6.0	O
09.7	6.1	Mu
10.5	6.0	O
10.5	6.0	Ba
10.6	6.0	Pi
10.6	6.0	Bu
10.7	6.0	Mu
11.5	6.0	O
14.6	6.0	M
15.3	6.0	L
16.6	6.0	O
16.6	6.0	Cr
16.6	5.9	Bu
17.6	6.0	O
17.6	6.0	Bu
18.6	6.0	O
18.6	6.0	Cr
20.5	6.0	O
20.5	6.0	Ba
20.6	6.0	Bu
21.3	6.0	L
21.5	6.0	O
21.6	6.0	Bu
22.6	6.0	V
23.5	6.0	Pi
23.5	6.0	Ba
23.6	6.4	Gr
23.7	6.0	Mu
24.5	6.0	Ba
24.6	6.0	O
24.6	6.0	Bu
24.6	5.6	Hu
25.7	6.1	Mu
26.5	6.0	Ba
26.6	6.2	M

VARIABLE STAR OBSERVATIONS September-October, 1916—Continued.

R Cor. Bor.

J.D.	Est.	Obs.
242		
1126.7	6.1	Mu
27.6	> 6.0	S
27.6	6.0	Cr
27.6	6.0	Bu
28.5	6.0	O
29.5	6.0	O
29.6	6.0	Bu
30.7	6.1	Mu
31.6	6.2	M
32.5	6.0	O
32.5	6.0	Ba
32.7	6.1	Mu
33.5	6.0	Ba
33.5	6.9	Sc
33.5	6.0	O
33.6	6.0	Cr
33.6	6.0	Bu
33.7	6.1	Mu
34.5	6.0	O
35.5	6.0	O
35.5	6.0	Ba
35.7	6.2	Mu
37.5	6.0	O
37.6	6.0	Cr
39.5	6.0	O
42.5	6.0	O

154536
X Cor. Bor.

1113.6	<12.3	Bu
26.5	12.5	Ba

154539
V Cor. Bor.

1113.6	8.4	Bu
20.5	8.3	Ba
26.5	8.2	Ba
31.6	9.7	M
32.6	8.2	Ba

154615
R Serpentis

1046.4	8.9	Pe
62.4	9.5	Pe
65.4	9.6	Pe
66.4	9.5	Pe
74.4	9.7	Pe
75.4	9.8	Pe
79.4	10.0	Pe
96.4	10.1	Pe
98.4	10.1	Pe
1106.6	11.3	Pi
09.6	11.7	B
10.7	11.9	Ly
13.6	<10.9	Bu
15.7	<12.0	Ly
20.5	12.2	Ba

155229
Z Cor. Bor

1113.6	<11.1	Bu
24.5	13.2	Ba

155847
X Herculis

J.D.	Est.	Obs.
242		
1108.7	5.9	Mu
09.4	6.1	L
09.5	6.7	Nt
09.7	6.0	Mu
10.5	6.5	O
10.7	6.1	Mu
11.5	6.4	O
15.4	6.2	L
17.6	6.7	Nt
20.5	6.6	O
21.5	6.5	O
23.6	6.9	Nt
23.7	6.3	Mu
25.7	6.6	Mu
26.7	6.5	Mu
28.5	6.5	O
30.7	6.5	Mu
32.5	6.8	O
32.7	6.4	Mu
33.5	5.6	Ba
33.6	7.0	Nt
33.7	6.3	Mu
35.5	6.8	O
35.7	6.5	Mu
37.5	6.6	O
39.5	6.6	O
42.5	6.5	O

160118
R Herculis

1110.5	<13.3	Ba
13.6	<11.4	Bu
20.5	<13.0	Ba
32.6	<13.4	B

160210
U Serpentis

1106.6	10.3	Pi
09.6	10.1	B
10.5	10.2	Ba
13.6	10.5	Bu
20.5	9.5	Ba
26.5	9.0	Ba
26.6	9.0	M
32.6	8.7	Ba

160625
RU Herculis

1110.6	8.1	O
10.6	8.2	Ba
13.6	8.0	Bu
14.6	8.6	M
18.6	9.0	O
20.6	8.5	B
20.6	8.5	Ba
21.6	9.3	O
22.6	8.9	V
26.5	8.4	Ba
28.5	9.6	O

RU Herculis

J.D.	Est.	Obs.
242		
32.5	9.7	O
32.6	8.7	Ba
35.5	9.7	O
35.5	9.7	Pi
35.5	9.6	Wpi

161138
W Cor. Bor.

1109.6	9.3	B
10.6	9.5	O
10.6	9.2	Ba
10.7	9.4	Ly
13.6	9.4	Bu
15.7	9.7	Ly
20.6	10.0	Ba
22.8	10.1	Ly
26.5	10.8	Ba
26.6	10.7	M
32.6	11.1	Ba
33.5	10.9	O

162112
V Ophiuchi

1079.4	10.1	L
98.3	9.9	L

162119
U Herculis

1108.7	8.9	Mu
09.6	9.0	Gr
10.6	9.2	O
10.6	8.8	Ba
10.7	9.0	Ly
10.7	8.8	Mu
11.6	9.1	M
13.6	9.1	Bu
15.7	9.2	Ly
18.6	9.1	O
20.6	9.0	B
20.6	9.0	Ba
22.8	9.2	Ly
23.6	9.2	Gr
23.6	9.1	Pi
23.7	8.9	Mu
26.5	9.5	Ba
28.5	9.5	O
30.7	9.2	Mu
32.5	9.5	O
32.6	9.2	Ba
34.6	9.7	S
34.7	9.7	Ly
35.5	9.7	O
42.5	9.6	O

162542
g Herculis

1065.4	4.8	Pe

162807
SS Herculis

J.D.	Est.	Obs.
242		
1066.4	9.9	L
71.4	10.2	L
77.4	10.7	L
96.4	12.4	L
1106.4	<12.4	L
09.6	<12.7	Nt
20.6	<12.4	Ba
22.6	<11.4	V
24.5	12.3	Ba
26.5	12.0	Ba
32.5	11.6	Ba
35.6	11.1	B
35.6	11.3	Ba

163172
R Urs. Min.

1114.6	10.4	M
20.6	9.2	B
20.6	9.3	Ba
23.6	9.8	Pi
26.6	9.5	Ba
27.6	10.1	M
32.6	9.6	Ba
33.6	9.8	Bu
34.5	9.6	Wh

163137
W Herculis

1124.6	11.9	Hu
24.6	13.4	Ba
33.6	<11.6	Bu
34.6	13.5	M
35.6	13.2	B

163266
R Draconis

1106.7	<11.0	Pi
10.6	<11.6	Cr
10.8	<12.0	Ly
13.6	<12.2	Bu
15.7	11.9	Ly
21.6	<12.2	Bu
22.8	11.7	Ly
23.6	<12.0	Cr
24.6	11.9	Ba
24.7	<11.0	Wh
25.7	11.3	Ly
27.6	11.8	B
27.6	11.9	Cr
32.6	11.6	Ba
33.6	11.8	Cr
33.6	<12.2	Bn
34.6	11.8	M

164055
S Draconis

1114.6	8.7	M
20.6	9.2	Ba

S Draconis

J.D.	Est.	Obs.
242		
1126.6	9.0	Ba
33.6	9.1	Ba
33.6	9.7	Bu
35.5	9.0	Pi
35.5	9.1	WPi

164715
S Herculis

1113.6	12.4	Bu
14.6	11.5	M
24.6	11.8	Ba
32.6	11.0	B
33.5	10.9	Ba
33.6	12.8	Bu
35.6	10.9	Pi
35.6	11.5	Wpi

165631
RV Herculis

1110.6	10.3	Ba
11.6	10.5	M
13.6	10.5	Bu
20.5	10.2	O
20.6	10.7	B
20.6	10.3	Ba
24.6	11.0	Hu
26.6	10.3	Ba
32.6	10.5	Ba
33.6	10.2	Bu
35.5	10.4	O
35.6	10.1	Pi
35.6	10.1	Wpi
39.5	10.9	O

170627
RT Herculis

1109.6	<12.8	Nt
13.6	<12.6	Bu
24.6	<12.8	Ba
26.6	<12.8	B
33.6	<12.6	Bu

171333
68 *u* Herculis

1062.4	4.9	Pe
65.4	4.8	Pe

171401
Z Ophiuchi

1122.6	10.8	V
23.6	10.3	Ba
32.6	11.4	Ba

171723
RS Herculis

1108.7	11.0	Mu
10.6	<10.1	Pi
11.6	12.2	M
13.6	12.3	Bu
18.6	11.9	B

Variable Star Observations September-October, 1916—Continued

RS Herculis

J.D.	Est.	Obs.
242		
1123.6	12.2	Ba
23.7	<11.2	Mu
24.6	12.6	Hu
27.6	12.1	Nt
33.5	12.3	Ba
33.6	<12.6	Bu

172809
RU Ophiuchi

1124.5	<12.5	Ba
34.6	13.0	M

175111
RT Ophiuchi

1124.5	<12.7	Ba

175458
T Draconis

1112.6	9.2	M
15.6	9.9	Bu
21.6	10.9	B
22.6	10.6	V
23.6	10.8	Ba
33.6	9.5	Bu
35.5	10.3	Pi
35.5	9.8	Wpi

175519
RY Herculis

1115.6	9.4	Bu
18.6	9.7	B
20.5	9.5	O
20.6	9.6	Ba
26.6	9.8	Ba
29.5	10.2	O
32.6	10.3	Ba
33.6	9.8	Bu
35.5	10.5	O
39.5	10.8	O

180531
T Herculis

1110.6	11.2	Ba
10.7	10.9	Mu
11.6	11.4	M
15.6	11.3	Bu
20.6	11.8	B
20.6	11.7	Ba
23.5	10.2	Pi
26.6	<11.0	Cr
26.6	12.2	Ba
32.6	12.6	Ba
33.6	12.6	Bu

180565
W Draconis

1106.7	9.1	Pi
14.6	9.0	M
15.6	9.0	Bu
1120.6	8.9	B
20.6	9.0	Ba
26.6	9.0	Ba
32.6	8.9	Ba
33.6	9.3	Bu

180666
X Draconis

J.D.	Est.	Obs.
242		
1114.6	<11.6	M

180931
TV Herculis

1096.4	<11.4	L
1109.3	<11.6	L

181103
RY Ophiuchi

1110.6	8.5	Ba
20.6	7.5	Ba
22.6	7.9	V
26.6	8.0	M
26.6	7.7	Ba
32.6	7.8	Ba

181136
W Lyrae

1108.7	7.7	Mu
09.6	7.6	M
09.6	7.8	Bu
10.7	7.7	Mu
18.6	8.2	O
20.6	7.8	Ba
21.6	8.0	B
23.6	8.5	Cr
23.7	8.0	Mu
24.6	7.9	Ba
24.6	8.3	Hu
24.7	8.5	Wh
28.5	8.7	O
30.6	8.6	Cr
30.7	8.5	Mu
32.5	8.8	O
32.6	8.3	Ba
32.7	8.8	Wh
33.5	8.9	O
33.6	8.7	Pi
37.6	8.8	B
37.6	9.2	Cr
37.6	9.0	Gr
39.5	8.9	O
42.5	9.2	O

182224
SV Herculis

1123.6	12.9	Ba
27.6	13.5	B
33.6	<11.9	Bu

182218
V Sagittarii

1094	8.3	ϒ
95	8.3	ϒ
96	8.3	ϒ
97	8.3	ϒ

182306
T Serpentis

J.D.	Est.	Obs.
242		
1095	<11.0	ϒ
1106	10.8	ϒ
06.6	<10.8	Pi
09.6	9.6	ϒ
10	9.5	ϒ
11	9.6	ϒ
14	9.7	ϒ
16	9.8	ϒ
17	9.6	ϒ
21	9.6	ϒ
23	<9.5	ϒ
23.6	13.0	Ba
28	10.3	ϒ
30	10.9	ϒ
31	11.2	ϒ
32	11.0	ϒ
33	11.0	ϒ
33.6	<12.4	Bu
34	11.3	ϒ
35	11.3	ϒ
37	11.5	ϒ

182443
RW Lytae

1132.6	<13.5	B

183225
RZ Herculis

1109.6	8.7	Bu
20.6	9.4	Ba
26.6	9.5	Ba
29.6	9.8	M
32.6	9.6	Ba
37.5	10.1	O
39.5	10.3	O

183308
X Ophiuchi

1083.6	7.9	L
1109.3	6.6	L
09.6	7.0	Bu
10.8	7.0	Ly
15.7	6.8	Ly
20.6	6.8	Ba
22.7	6.7	Ly
25.6	6.8	V
25.7	6.7	Ly
26.6	6.8	M
26.6	6.6	Ba
32.6	6.6	Ba

184132
RY Lyrae

1110.6	<13.5	Ba
33.6	<12.3	Bu

184243
RW Lyrae

1110.6	<13.6	Ba
33,6	<11.8	Bu

184205
R Scuti

J.D.	Est.	Obs.
242		
1062.4	6.7	Pe
64.4	6.7	Pe
65.4	6.8	Pe
66.4	6.8	Pe
66.4	6.6	L
67.4	6.9	Pe
70.4	7.0	Pe
71.4	7.0	Pe
71.4	6.9	L
74.4	7.1	Pe
75.4	7.1	Pe
76.4	7.2	Pe
77.4	7.4	Pe
77.4	6.9	L
79.4	7.3	Pe
80.4	7.3	Pe
81.4	7.2	Pe
83.4	7.1	L
87.3	7.1	L
89.4	6.5	L
92.4	6.1	L
96.4	5.9	Pe
96.4	5.6	L
97.4	5.8	Pe
98.4	5.5	L
1108.4	5.3	L
08.7	5.7	Mu
09.3	5.3	L
09.6	5.2	Bu
09.6	5.3	O
09.6	4.9	Cr
09.7	5.6	Mu
10.5	5.3	O
10.5	5.5	Ba
10.6	5.2	Pi
10.6	5.2	Bu
10.6	5.2	Cr
10.7	5.6	Mu
11.5	5.3	O
13.6	5.4	Bu
15.3	5.0	L
16.6	5.2	O
16.6	5.2	Cr
16.6	5.4	Bu
17.6	5.3	O
17.6	5.4	Bu
18.6	5.4	O
19.6	5.4	Bu
20.5	5.4	O
20.5	5.4	Ba
20.6	5.3	Cr
20.6	5.4	Bu
21.3	5.0	L
21.5	5.4	O
21.6	5.6	Bu
21.7	5.5	Mu
23.5	5.5	Ba
23.6	5.5	Pi
23.6	5.3	Cr

R Scuti

J.D.	Est.	Obs.
242		
1123.7	5.5	Mu
24.5	5.5	Ba
24.6	5.4	O
24.6	5.5	Bu
24.7	5.5	Mu
25.7	5.5	Mu
26.5	5.5	Ba
26.6	5.2	M
26.7	5.5	Mu
27.6	5.4	Cr
27.6	5.6	Bu
28.5	5.8	O
29.5	5.4	O
30.6	5.8	Bu
30.7	5.5	Mu
31.8	5.5	Mu
32.5	5.7	O
32.5	5.7	Ba
32.6	5.8	Wh
32.7	5.6	Mu
33.5	5.8	O
33.5	5.7	Ba
33.6	5.6	Cr
33.6	5.8	Bu
33.7	5.7	Mu
34.5	5.8	Sc
34.5	5.8	O
34.6	5.8	Pi
34.6	5.5	Wpi
35.5	5.8	O
35.5	5.8	Ba
35.6	5.6	Cr
35.6	5.4	Bu
35.7	5.7	Mu
37.5	5.8	O
37.6	5.4	Cr
37.6	5.2	Bu
39.5	5.9	O
42.5	5.8	O

185032
RX Lyrae

1110.6	<13.3	Ba
34.6	<13.0	M

185634
Z Lyrae

1110.6	<13.3	Ba
32.7	<13.3	Ba

190108
R Aquilae

1071.4	6.0	L
96.4	6.1	L
1108.4	6.5	L
09.6	6.4	Bu
12.6	6.3	M
16	8.0	ϒ
18	8.1	ϒ
18.6	6.1	B
20.6	6.9	Ba

VARIABLE STAR OBSERVATIONS September-October, 1916—Continued.

R Aquilae

J.D.	Est.	Obs.
242		
1125.6	7.3	V
26.6	7.1	Ba
33.5	7.4	Ba
33.6	6.6	Bu
34	8.2	ϒ

190529
V Lyrae

1124.6	<13.0	Ba
33.6	<12.3	Bu

190926
X Lyrae

1122.6	9.0	M
23.6	8.8	Ba
33.6	8.9	Pi
33.6	8.7	Ba
33.6	9.7	Bu
35.6	9.0	Pi
35.6	8.5	Wpi

190967
U Draconis

1114.6	11.8	M
27.6	10.6	M

191019
R Sagittarii

1071.4	7.9	L
76.4	8.3	Pe
79.4	8.5	Pe
81.4	8.3	Pe
96.4	8.7	Pe
98.3	8.1	L
1106.5	8.5	Pi
09.6	8.6	Bu
24.5	9.6	Ba
33.5	10.2	Ba

191033
RY Sagittarii

1066.4	< 9.5	L
71.4	< 9.7	L
77.4	<10.5	L
81.4	<10.0	L
96.4	<10.5	L
98.3	<19.5	L
1105.4	< 10.5	L
06.6	<10.0	Pi
08.4	<10.5	L
09.3	<10.5	L
13.6	<11.0	Bu
24.5	<11.0	Ba
33.5	<12.0	Ba
33.6	<11.1	Bu

191350
TZ Cygni

1109.6	10.4	Bu
23.6	10.7	Ba
33.5	10.2	Ba

191637
U Lyrae

J.D.	Est.	Obs.
242		
1120.6	9.3	Ba
22.6	10.2	M
26.6	9.3	Ba
33.6	9.5	Ba
33.6	8.6	Bu
35.6	10.5	Pi
35.6	10.4	Wpi

191808
Z Vulpeculae

1078	7.5	ϒ
93	7.7	ϒ
94	7.7	ϒ
95	7.3	ϒ
96	7.3	ϒ
1109.3	7.1	ϒ
10.3	7.5	ϒ
11.3	6.9	ϒ
16.4	7.4	ϒ
17.3	6.8	ϒ
21.3	7.3	ϒ
23.3	7.3	ϒ

192928
TY Cygni

1109.6	11.4	Bu
10.6	<13.3	Ba

193311
RT Aquilae

1083.6	11.5	L
96.4	11.8	L
1109.6	<12.4	Bu
24.6	13.0	Ba

193449
R Cygni

1062.4	6.4	Pe
65.4	6.7	Pe
67.4	6.7	Pe
79	8.8	ϒ
93	7.8	ϒ
94	7.8	ϒ
95	7.9	ϒ
1109	8.7	ϒ
09.6	7.5	Bu
10	7.8	ϒ
14	9.5	ϒ
16.6	8.0	O
16.6	8.8	Cr
17	8.5	ϒ
20	8.6	ϒ
20.6	8.0	Ba
21	8.9	ϒ
23.8	8.7	M
24.6	9.0	Hu
26.6	8.2	Ba
27	9.4	ϒ
27.6	9.0	S
33.5	8.5	Ba
33.6	7.8	Bu

R Cygni

J.D.	Est.	Obs.
242		
1134.6	9.0	Pi
34.6	9.1	Wpi
35	9.5	ϒ
35.5	9.0	O
37.7	9.4	S

193509
RV Aquilae

1109.6	< 12.4	Bu
24.6	13.3	Ba
33.5	13.1	Ba

193732
TT Cygni

1102.6	7.9	L
09.6	8.2	Bu
15.6	8.3	L
23.6	7.2	Ba
24.6	7.9	Hu
33.5	7.1	Ba
36.6	9.3	M

194048
RT Cygni

1078	10.0 ±	ϒ
81	8.8	L
94	10.0 ±	ϒ
95	10.0 ±	ϒ
1105	10.0 ±	ϒ
09	10.0 ±	ϒ
09.6	11.6	Bu
10	10.0 ±	ϒ
14	10.0 ±	ϒ
20.6	9.4	Ba
23.8	9.5	M
24.6	8.9	Hu
26.6	9.2	Ba
26.6	9.1	Le
27	9.9	ϒ
27.6	9.3	S
33.6	8.7	Ba
34.7	8.8	Wh
35	8.7	ϒ
35.5	9.7	O
35.6	8.8	Pi
35.6	8.9	Wpi
37	8.6	ϒ
37.7	8.6	S

194348
TU Cygni

1109.6	11.8	Bu
20.6	12.4	Ba
23.8	<11.2	M
24.6	12.6	Hu
26.6	12.7	Ba
33.6	<12.2	Bu
34.7	<11.3	Wh
35.6	<11.7	Pi
35.6	<11.7	Wpi

194604
X Aquilae

J.D.	Est.	Obs.
242		
1123.6	<12.3	Nt
24.6	<13.0	Ba
26.6	13.2	B
36.6	<12.3	Bu
37.6	13.5	B

194632
χ Cygni

1065.4	<11.7	Pe
67.4	<12.4	Pe
1109.6	<12.0	Bu
10.6	<13.4	Ba
13.6	<12.0	Bu
27.6	11.9	M
33.6	<12.0	Bu
34.7	<11.3	Wh

195116
S Sagittae

1108.7	6.0	Mu
09.6	5.8	O
09.7	6.2	Mu
10.5	5.7	O
10.7	5.6	Mu
11.5	5.4	O
17.6	5.7	O
18.6	6.0	O
20.5	5.4	O
21.5	5.5	O
21.7	5.7	Mu
23.7	5.8	Mu
24.6	5.8	O
24.7	5.5	Mu
25.7	5.9	Mu
26.7	5.7	Mu
28.5	5.4	O
29.5	5.4	O
30.8	5.5	Mu
31.7	5.5	Mu
32.5	5.7	O
32.7	5.7	Mu
33.5	5.9	O
33.7	6.0	Mu
34.5	6.1	O
35.5	6.1	O
35.7	5.6	Mu
37.5	5.7	O
39.5	5.4	O
42.5	6.0	O

195849
Z Cygni

1094	8.6	ϒ
95	8.2	ϒ
1102.6	8.0	L
09	8.6	ϒ
09.6	8.3	Bu
10	8.6	ϒ
14	8.8	ϒ

Z Cygni

J.D.	Obs.	Est.
242		
1123	8.6	ϒ
23.6	7.6	Ba
23.8	8.6	M
27	8.5	ϒ
33.6	7.9	Ba
33.6	7.4	Bu
34.6	8.4	Pi
34.6	9.0	Wpi
35	8.9	ϒ

200212
SY Aquilae

1109.6	12.4	Bu
10.6	<12.2	Ba
23.6	<12.4	Ba
26.6	13.4	B
33.6	<12.4	Nt
33.6	12.4	Bu
37.6	13.3	B

200357
S Cygni

1123.6	12.8	Ba
33.6	12.5	Ba
33.6	12.2	Bu

200514
R Capricorni

1127.6	10.9	M

200647
SV Cygni

1108.7	9.1	Mu
23.6	8.0	Ba
23.6	9.0	Mu
24.6	8.8	Hu
26.6	8.9	M
32.8	9.2	Pi
33.6	8.1	Ba

200635
RY Cygni

1094	11 ±	ϒ
95	11.0 ±	ϒ

200715a
S Aquilae

1067.4	11.5	L
71.4	11.1	L
77.4	11.4	L
83.6	10.8	L
96.4	10.3	L
1102.6	10.1	L
09.3	10.1	L
09.6	9.3	Bu
11.6	10.2	B
13.6	9.6	M
23.6	9.4	Ba
33.6	9.4	Ba

Variable Star Observations September-October, 1916—Continued.

200715b
RW Aquilae

J.D.	Est.	Obs.
242		
1109.6	8.9	Bu
11.6	9.2	B
13.6	9.4	M
23.6	9.0	Ba
33.6	9.0	Ba

200747
RX Cygni

1108.7	8.0	Mu
23.6	7.8	Mu

200812
RU Aquilae

1009.6	11.4	B
23.6	12.5	Ba
33.6	12.6	Ba

200906
Z Aquilae

1109.6	10.0	B
18.6	10.9	B
23.6	11.2	Ba
33.6	11.9	Ba

200916
R Sagittae

1111.6	9.1	B
13.6	8.8	M
17	8.8	ϒ
23	8.9	ϒ
23.6	8.8	Ba
33.6	9.4	Ba
34	9.5	ϒ
35	9.5	ϒ
37	9.4	ϒ

200938
RS Cygni

1095	8.9	ϒ
1102.6	9.0	L
14.6	8.8	M
23.6	8.0	Ba
34.6	9.0	Pi
34.6	9.0	Wpi
35.6	8.0	Ba

201008
R Delphini

1110.6	<12.8	Ba
23.6	<12.5	Ba
24.6	<11.3	Wh
26.6	13.2	B
34.6	<10.8	Pi
35,6	13.5	Ba
37.6	12.7	B

201521
RT Capricorni

1083.4	6.6	L
96.4	6.7	L
1109.4	6.7	L
24.5	6.6	Ba

RT Capricorni

J.D.	Obs.	Est,
242		
1127.6	7.5	M
32.7	7.7	Pi
33.5	7.0	Ba

201130
SX Cygni

1110.6	11.1	Ba
14.6	11.6	M
23.6	12.0	Ba
35.6	12.0	Ba

201647
U Cygni

1084	<10.0	ϒ
1102.6	11.3	L
09	11.5	ϒ
09.6	10.6	Bu
10.6	10.6	Pi
13.6	10.6	Bu
23.6	9.0	Ba
26.6	10.4	M
27	11.2	ϒ
32.8	10.0	Pi
35	9.7	ϒ
35.6	8.6	Ba
37.7	<9.8	S

202539
RW Cygni

1113.6	8.0	Bu
14.6	8.4	M
15.6	8.5	L
23.6	8.0	Ba

202817
Z Delphini

1113.6	11.7	Bu
23.6	12.1	Ba
25.6	<11.7	V
32.6	<11.2	M
33.6	<12.0	Nt
34.6	<12.4	Bu

202946
SZ Cygni

1077.4	9.9	L
81.6	9.1	L
1102.6	9.5	L
10.5	8.7	Ba
11.6	8.8	Le
17.6	9.5	Le
20.5	9.5	Ba
23.6	9.5	Ba
24.5	9.0	Ba
26.5	8.6	Ba
32.5	9.3	Ba
33.5	9.5	Ba
34.7	9.7	Ba
36.6	9.6	M
38.7	9.6	Le

SZ Cygni

J.D·	Est.	Obs.
242		
1139.7	8.9	Le
40.7	8.7	Le
41.7	8.7	Le
42.7	8.9	Le
43.7	9.0	Le

202954
ST Cygni

1113.6	10.0	Bu
21.6	9.8	Bu
23.6	10.4	Ba
32.6	9.6	Hu
34.6	9.9	Pi
34.6	9.6	Wpi

203226
V Vulpeculae

1078	9.1	ϒ
93	9.0	ϒ
94	9.0	ϒ
95	9.0	ϒ
96	8.9	ϒ
1109.3	8.6	ϒ
10.4	8.4	ϒ
11.4	8.6	Ba
16.4	8.6	ϒ
17.3	8.6	ϒ
21.3	8.5	ϒ
23.3	8.6	ϒ
23.6	8.6	Ba
27.6	8.6	M
39.6	8.8	O

203611
Y Delphini

1110.6	<13.0	Ba
23.7	12.3	Ba
26.6	13.5	B
37.6	13.3	B

203816
S Delphini

1130.6	9.8	M

203847
V Cygni

1095	8.6	ϒ
96	8.2	ϒ
1113.6	<12.4	Bu
23.7	10.6	Ba
23.8	11.0	M

204016
T Delphini

1109.6	11.2	B
13.6	11.5	Bu
23.7	12.1	Ba

204318
V Delphini

J.D.	Obs.	Est.
242		
1094	<11.5	ϒ
1110.6	<12.8	Ba
13.6	<12.0	Bu
26.6	<13.0	B
33.6	<12.0	Bu
37.6	<12.8	B

204405
T Aquarii

1120.6	9.9	B
24.5	9.0	Ba
26.6	9.0	Nt
27.6	9.0	M
32.6	8.4	Ba
32.7	9.9	Pi
37.6	7.9	Hu

204846
RZ Cygni

1132.7	13.2	Ba
33.6	<12.0	Bu
36.6	<10.6	M

205017
X Delphini

1124.6	13.7	Ba
26.6	13.2	B
26.6	12.9	Nt
37.6	13.5	B

205923
R Vulpeculae

1123.7	7.5	Ba
27.6	8.6	M
39.5	9.1	O

210116
RS Capricorni

1109.3	8.6	L
10.6	8.4	Pi
10.6	8.4	Wpi
23.7	8.6	Mu
24.5	7.8	Ba
26.6	8.4	M
30.7	8.5	Mu
32.7	8.5	Pi
33.5	7.9	Ba

210129
TW Cygni

1109.6	12.2	Bu
26.6	12.5	Ba

210868
T Cephei

1083.6	9.1	L
1109.6	8.7	Bu
10.5	8.8	O
20.5	8.6	O
24.6	7.5	Ba
28.5	8.0	O
28.6	7.8	M

T Cephei

J.D.	Est.	Obs.
242		
33.6	8.0	Bu
34.5	7.9	S
35.5	8.2	O
37.6	8.0	Cr
39.5	8.0	O

211614
X Pegasi

1113.6	10.4	Bu
23.7	9.8	Ba
29.5	9.3	O
32.5	9.4	O
35.5	9.4	O

211615
T Capricorni

1124.6	13.0	Ba
32.7	<11.8	Pi
33.5	12.9	Ba

213044
W Cygni

1171.4	5.6	L
77.4	5.7	L
81.6	5.9	L
83.6	5.8	L
89.4	5.7	L
92.4	5.9	L
96.3	5.8	L
98.4	5.8	L
1102.6	6.0	L
05.3	6.0	L
08.4	6.2	L
09.3	6.1	L
13.6	6.4	Bu
15.3	6.0	L
21.3	6.1	L

213678
S Cephei

1113.6	11.8	Bu
24.6	11.4	Ba
29.6	11.8	M
34.6	<10.2	S

213753
RU Cygni

1113.6	7.8	M
13.6	7.6	Bu
26.6	7,9	Ba

213843
SS Cygni

1071.4	9.4	L
77.4	10.9	L
78.4	11.4±	ϒ
81,6	11.7	L
83.6	11.5	L
89.4	<10.0	L
92.4	10.5	L
95.4	11.4±	ϒ

Variable Star Observations September-October, 1916—Continued.

SS Cygni

J.D.	Est.	Obs.
242		
96.4	11.4±	ϒ
96.3	10.0	L
98.4	10.3	ϒ
98.4	8.3	L
99.4	8.2	ϒ
1100.4	8.4	ϒ
00.6	8.6	L
02.3	8.1	L
02.6	8.1	L
03.4	8.3	ϒ
05.3	8.2	L
06.5	8.5	Pi
07.3	8.6	ϒ
08.4	8.3	L
08.7	8.6	Mu
09.3	8.3	L
09.3	8.6	ϒ
09.5	8.6	Nt
09.5	8.6	Sc
09.6	8.7	O
09.6	8.6	Bu
09.6	9.0	B
09.6	8.4	Cr
10.3	8.9	ϒ
10.5	8.8	O
10.5	8.8	Ba
10.6	9.2	B
10.6	8.8	Bu
10.6	8.5	Cr
10.7	8.5	Mu
10.8	8.7	Ly
11.3	9.1	ϒ
11.4	9.0	ϒ
11.5	8.7	O
11.6	9.1	M
11.6	9.0	B
11.6	8.8	Cr
11.6	8.7	Sc
11.6	9.2	Le
12.6	9.5	M
12.7	8.8	Ly
13.6	9.4	Bu
13.6	9.7	M
14.3	10.1	ϒ
14.6	9.8	M
15.3	9.8	L
15.7	9.1	Ly
16.3	11.3	ϒ
16.6	10.9	O
16.6	10.7	B
16.6	10.8	Cr
16.6	10.5	Bu
16.7	10.5	M
17.3	11.3	ϒ
17.6	11.0	O
17.6	10.6	O
17.6	11.1	Bu
18.6	10.7	B
18.6	10.8	Cr
18.6	11.4	Bu
242		
1119.6	11.0	Cr
19.6	11.7	Bu
20.3	11.3	ϒ
20.5	<10.9	O
20.5	11.2	Ba
20.6	11.5	B
20.6	11.1	Cr
20.6	11.8	Bu
21.3	11.3	V
21.3	11.3	ϒ
21.6	11.4	B
21.6	11.4	Cr
21.6	11.7	Bu
22.6	11.2	M
22.6	11.6	Bu
23.3	11.3	ϒ
23.5	11.4	Pi
23.6	11.5	Cr
23.6	11.5	Nt
23.6	11.3	B
23.6	11.4	Ba
23.7	11.1	Mu
23.8	11.4	M
24.5	11.4	Ba
24.6	11.6	Hu
24.6	11.5	Cr
24.6	11.7	Bu
25.6	11.7	Cr
25.6	<11.3	V
25.7	11.0	Ly
26.5	11.6	Ba
26.6	11.5	B
26.6	12.0	Cr
26.6	11.5	Nt
27.6	11.4	Nt
27.6	11.9	Cr
27.6	10.8	M
27.6	11.8	B
27.6	11.5	Bu
28.3	11.3	ϒ
28.6	10.7	M
28.6	11.5	Cr
29.6	10.5	M
29.6	11.6	B
29.6	11.5	Cr
29.6	11.5	Bu
30.3	11.3	ϒ
30.6	10.3	M
30.6	11.6	Cr
30.6	11.4	Bu
30.7	11.0	Mu
31.3	11.4	ϒ
32.3	10.5	ϒ
32.5	9.8	Ba
32.5	10.1	O
32.6	9.8	Wh
32.6	10.0	M
32.6	10.2	B
32.6	9.9	Cr
32.6	10.1	Bu
242		
1132.8	9.7	Pi
33.3	9.0	ϒ
33.5	9.4	Ba
33.5	9.6	O
33.5	9.0	Pi
33.6	9.2	Nt
33.6	9.4	Cr
33.6	9.5	M
33.6	9.5	Sc
33.6	9.4	Bu
33.7	10.2	Bu
33.4	9.2	ϒ
34.5	8.9	O
34.6	9.3	M
34.6	9.0	Pi
34.6	9.5	Cr
34.6	8.7	Wpi
34.6	9.4	Bu
34.7	9.2	Ba
35.3	9.1	ϒ
35.5	8.8	O
35.5	9.2	Ba
35.6	8.9	Pi
35.6	9.1	Cr
35.6	8.7	Wpi
35.6	8.8	Bu
35.6	9.3	B
36.6	9.6	M
36.6	9.0	Cr
37.3	10.1	ϒ
37.5	9.4	O
37.5	9.2	Cr
37.6	9.8	M
37.6	9.8	Cr
37.6	9.9	Hu
37.6	9.4	Bu
37.6	9.8	B
37.7	9.8	S
37.7	9.8	Bu
38.6	10.0	M
38.7	10.1	Le
39.5	10.4	O
39.7	10.4	Le
40.7	10.4	Le
41.7	11.1	Le
42.7	11.2	Le
43.7	11.2	Le

213937
RV Cygni

J.D.	Est.	Obs.
1093	8.0	ϒ
95	7.7	ϒ
1102.6	6.5	L
05	7.8	ϒ
09	8.6	ϒ
10	7.8	ϒ
13.6	7.7	M
14	8.0	ϒ
24.6	6.8	Ba
24.6	7.9	Hu
27	8.0	ϒ
242		
1132.8	7.9	Pi
35	8.0	ϒ

214024
RR Pegasi

J.D.	Est.	Obs.
1124.6	<13.2	Ba
29.5	<11.2	O
32.6	<12.6	Pi
37.6	<13.5	B

215605
V Pegasi

J.D.	Est.	Obs.
1121.5	<10.6	O
24.6	<13.0	Ba
27.6	13.8	B

215934
RT Pegasi

J.D.	Est.	Obs.
1124.6	11.0	Ba
25.6	<11.3	V

220412
T Pegasi

J.D.	Est.	Obs.
1126.6	13.5	B
32.6	<11.3	Ba

220613
Y Pegasi

J.D.	Est.	Obs.
1125.6	10.4	V
26.6	10.3	B
29.5	11.1	O
32.6	11.0	M
32.6	11.1	Pi
32.6	10.7	Ba
35.5	11.0	O
39.5	11.2	O

220714
RS Pegasi

J.D.	Est.	Obs.
1125.6	<11.3	V
26.6	12.3	B
32.6	<12.1	M
32.6	<12.5	Pi
32.6	<13.0	Ba

222439
S Lacertae

J.D.	Est.	Obs.
1111.5	<10.4	O
23.6	12.8	B
24.6	12.7	Ba
27.6	12.8	B

223841
R Lacertae

J.D.	Est.	Obs.
1133.6	9.6	M
37.6	9.3	M

225120
S Aquarii

J.D.	Est.	Obs.
1125.6	8.5	Ba
29.6	8.5	M
32.7	9.0	Pi
33.5	8.7	Ba

225914
RW Pegasi

J.D.	Obs.	Est.
242		
1109.6	10.0	Bu
20.6	10.5	B
23.7	10.6	Mu
24.6	10.6	Ba
25.6	10.9	V
30·6	11.0	M
30.7	10.5	Mu
32.6	11.4	Pi

230110
R Pegasi

J.D.	Est.	Obs.
1074.4	<11.6	Pe
74.6	12.7	Pe
79.4	12.7	Pe
81.4	12.5	Pe
97.4	12.4	Pe
98.4	12.4	Pe
1124.6	12.4	Ba
26.6	12.2	Nt
32.6	12.5	Pi
32.6	11.8	Ba
32.7	<11.3	Wh

230759
V Cassiop

J.D.	Est.	Obs.
1071.4	9.3	Pe
74.4	9.8	Pe
76.4	9.7	Pe
79.4	9.7	Pe
81.4	9.8	Pe
97.4	11.1	Pe
1109.6	11.6	Bu
16.6	11.1	B
24.6	12.0	Ba
28.5	<11.2	Pi
37.6	<11.2	M
37.6	12.0	Hu
38.7	<11.0	Wh

231425
W Pegasi

J.D.	Est.	Obs.
1109.6	10.8	Bu
24.6	10.7	Ba
25.6	10.9	V
30.6	10.9	M
32.6	10.2	Hu

231508
S Pegasi

J.D.	Est.	Obs.
1074.4	9.6	Pe
76.4	9.7	Pe
79.4	9.8	Pe
81.4	9.7	Pe
96.4	10.1	Pe
97.4	11.3	Pe
98.4	11.4	Pe
1132.6	11.9	Ba

Variable Star Observations September-October, 1916—Continued.

233335
ST Androm.

J.D.	Est.	Obs.
242		
1109.6	9.3	O
09.6	9.0	Bu
15.7	9.5	Ly
18.6	9.1	B
24.6	9.3	Ba
25.6	9.3	Hu
27.6	10.0	S
28.5	9.5	O
29.6	9.5	M
32.5	10.0	Pi
35.5	9.6	O

233815
R Aquarii

J.D.	Est.	Obs.
242		
1081.4	8.3	Pe
98.4	6.5	Pe
1124.7	5.9	Ba
29.6	6.2	M
32.7	6.5	Pi

233956
Z Cassiop.

J.D.	Est.	Obs.
1109.6	11.4	Bu
24.7	11.2	Ba
37.6	11.7	M

235209
V Ceti

J.D.	Est.	Obs.
242		
1124.7	10.5	Ba
32.6	11.2	Pi
37.6	10.3	M

235350
R Cassiop.

J.D.	Est.	Obs.
1109.6	<12.4	Bu
23.6	12.6	B
27.6	10.6	M
32.6	12.5	Ba
37.6	12.0	B

235525
Z Pegasi

J.D.	Est.	Obs.
242		
1111.5	10.6	O
24.7	10.5	Ba
28.7	11.1	V
30.6	10.5	M
32.5	10.5	O
32.6	10.7	Pi
35.5	10.4	O
39.5	10.5	O

235939
SV Androm.

J.D.	Est.	Obs.
242		
1109.6	11.3	Bu
18.6	11.8	B
24.7	11.9	Ba
32.6	12.2	Pi
34.6	12.3	Hu

No. of observations 1580; No. of stars observed 233; No. of observers 20.

The fact that the sum total of observations this past year does not equal that of the past two years is entirely due to the fact that of late we have endeavored to seek new and difficult fields, and thus extend the scope of the work rather than try for a greater number of observations of the better observed variables. We have also discontinued the frequent observations of many variables.

The Association again renews its thanks to Professor E. C. Pickering for his continuing interest in our organization, and to Professor H. C. Wilson, Editor of Popular Astronomy for promoting our interest by the publication of the reports. We also wish to express our obligation to Mr. Leon Campbell of the Harvard College Observatory staff for his very active interest in the welfare of the Association, and for the ever ready assistance he offers those of us who seek his aid. Mr. Campbell's lists of magnitudes sent out to members each month are of great value, and increase the efficiency of the service.

During the past year 291 Variable stars of long period have been observed, and the Secretary has distributed over five hundred blue prints to members.

In conclusion the secretary wishes to thank the members of the Association for their hearty coöperation and support, which has resulted in a highly prosperous year and promoted the interest of an organization we can well be proud of and which it is a pleasure to serve.

The following members contributed to this month's report:—Messrs. Bancroft, Bouton, Burbeck, Crane, Eaton, Gregory, Hunter, Lacchini, Leonard, Lindsley, McAteer, Mundt, Nolte, Olcott, D. B. Pickering, S. W. Pickering, Schulmaier, Vrooman, Whitehorn, Yendell, and Miss Swartz.

William Tyler Olcott,
Corresponding Sec'y.

Norwich, Conn.
Oct. 10, 1916.

ANNUAL REPORT OF THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS FOR THE YEAR ENDING OCT. 10, 1916.

RECORD OF OBSERVATIONS

	Baldwin (Bl)	Bancroft (Ba)	Bouton (B)	Burbeck (Bu)	Crane (Cr)	Eaton (E)	Gray (G)	Gregory (Gr)	Hoge (Ho)	Hunter (Hu)	Lacchini (L)	Leonard (Le)	Lindsley (Ly)	Miss Ludeke (Lu)	Mach (Ma)	McAteer (M)	Mundt (Mu)	Nolte (Nt)	Olcott (O)	de Perrot (Pe)	D. B. Pickering (Pi)	S. W. Pickering (Wpi)	Richter (R)	Schulmaier (Sc)	Spinney (Sp)	Miss Swartz (S)	Vrooman (V)	Whitehorn (Wh)	Yendell (T)	Miss Young (Y)	Additional Obs.	Total number of Observations	Number of stars observed	Number of observers
Nov.		248	41	40	15	15	16		20	36	39		31		45	106	24	23	100		73		122		25	9	15			18	7	1068	178	25
Dec.		157	33	39	3	21			27	40	47		59		61	64	39	46	62		100		81		29	5				38	15	966	179	21
Jan.		30	59	42	16	25	8		20	30	16		36		21	38	24	33	49		11		32			10	5			6	3	514	134	21
Feb.		62	14	14	20	47			8	20	49		17		9	38	14	6	40		32		46		6	12	17			17		488	127	20
Mar.			43	41		38			17	10	56		9		1	43	5	31			46		54			14	11			12		431	121	16
Apr.		79	20	41		35			4		40				2	68	21	21	53		66		12		27	13	18			16		536	153	17
May		228	8	68	8	82			18		28				4	59	34	17	63		41		40				10	1		29		738	175	18
June	14	282	48	30	18	18	11		6	16	49			14	12	145	43		66		72	4	35		17		45	8		30		983	188	22
July		352	46	2	25	31		3		9	59			23	30	148	64	21	65		52	23	84	10	49	32	40	11	34			1213	196	23
Aug.		121	28		13	90	31	7			78	67		37	52	113	119		25	39	32	17	77	14			49	14	28			1051	170	21
Sept.	41	482	119	64	24	42		6		9	78	57			65	139	53	52	36	104	55	14	66	20	15	21	50	23	49			1684	196	25
Oct.		362	97	189	51			5		26	93	16	45			170	72	23	153		101	24		5		19	20	21	88			1580	232	20
Total	55	2403	556	570	193	444	66	21	120	196	632	140	197	74	302	1131	512	273	712	143	681	82	649	49	168	135	280	78	199	166	25	**11252**		

ANNUAL RECORD OF THE ASSOCIATION.

Year	Number of Observers	No. of stars Observed	Number of Observations	Total
1912	19	175	6180	
1913	20	200	12914	
1914	28	255	14506	
1915	29	282	14724	
1916	30	290	11252	**59576**

GENERAL NOTES.

Erratum.—Professor Barnard calls attention to the fact that in Plate XXIX in the October number of POPULAR ASTRONOMY the titles were interchanged in making up the form for the press. The upper of the two photographs was made with the 6-inch Bruce lens in 1916 and the lower with the 6-inch Willard lens in 1894.

Dr. W. Zurhellen, assistant at the Royal Observatory, Berlin, died on July 15, aged thirty-six years. It is noted in *The Observatory* that Dr. Zurhellen was one of the members of the Eclipse Expedition from the Berlin Observatory to the Crimea to observe the total eclipse of 1914, August 21. The last news which we had obtained of this expedition was that Zurhellen, being of military age, had been interned in Russia, whilst the older members of the expedition were allowed to return to Germany. After a year in Russia, Zurhellen was allowed to return to Germany; he joined the Bonn contingent, and was killed in the fighting in north France. *Science*, Sept. 29, 1916.

Professor William W. Payne, director of the Elgin Observatory, formerly professor of Mathematics and Astronomy and director of the Goodsell Observatory of Carleton College, and the founder of POPULAR ASTRONOMY, was granted the degree of Doctor of Science by Carleton College October 13, 1916, on the occasion of the celebration of the fiftieth anniversary of the founding of the college. At the same time the degree of Doctor of Science was conferred upon Professor Lucian W. Chaney, and the degree of the More Humane Letters upon Mrs. Margaret Evans Huntington and Professor Horace Goodhue. All of these persons are retired members of the Carleton College faculty.

New Observatory for the University of Arizona.—A gift of $60,000 for an observatory and 36-inch telescope has been given to the University of Arizona by a donor whose name is withheld. *Science*, Oct. 27, 1916.

NOTES FROM THE YERKES OBSERVATORY.

Mr. John E. Mellish, who has been at the Observatory for the past fifteen months as Volunteer Research Assistant, will soon leave to take charge of the well equipped private observatory at Leetonia, Ohio, of Mr. Elmer Harrald, Secretary and Manager of the Crescent Wood Working Machine Company. Mr. Mellish's duties will include the use of the telescope for visitors on certain public nights, but he will have ample opportunity for personal observation with his own telescopes, as well as with those of the observatory, and he will also have improved facilities for continuing his work in making reflecting telescopes. Leetonia is on the main line of the Pennsylvania Railroad, not far from Youngstown and Alliance, in both of which centers there are many persons interested in Astronomy. Mr. Mellish is to be congratulated on this well deserved recognition.

Mr. George S. Monk, recently of the staff of the Mount Wilson Solar Observatory, began work on October 1st as Assistant in Stellar Spectroscopy. He is enrolled at the same time for his graduate work for the Ph. D. degree in the University of Chicago, from which institution he received the Bachelor's degree in 1914.

Miss Hannah B. Steele, Assistant in the Stellar Parallax Work, is also a candidate for the Doctor's degree.

Miss Alice H. Farnsworth, B. A., Mount Holyoke, 1916, has begun her studies, chiefly with Mr. Parkhurst, for the degree of M. S. **Misses Gushee** and **Wickham,** computers in parallax work, are also candidates for the Master's degree.

Mr. Stanley H. Hughes, for the last four years in charge of the Department of Lantern Slides and Prints, left on October 1st for further study at the University of Washington. **Mr. George C. Blakslee,** who has had much experience in landscape and studio work, and who has spent his summers for some years on Lake Geneva in professional photography, will hereafter be in charge of this department.

Mr. Julius Lemkowitz, during the past year computer in the Observatory, has gone to Princeton as Observatory Assistant.

Mr. Edwin P. Hubble, Fellow in Astronomy, for the past two years in charge of the two-foot reflector, is spending the autumn and winter quarters in theoretical studies at the University of Chicago.

The summer of 1916 has been remarkable for the clearness of the sky, and at the same time nights with fine seeing have been more numerous than usual. These conditions are of course related to the drought during the summer. The gain in hours of night observation for the summer is 35 per cent over the normal. During the six months from January to June there was an accumulated gain of 68½ hours, so that the total gain over the normal for the first nine months of 1916 is 19 per cent. The figures are as follows:

HOURS OF OBSERVATION WITH 40-INCH TELESCOPE.

Month	1916	Mean for Decade	Gain 1916
July	210½	146	64½
August	210½	148½	62
September	188	157	31
Total	609	451½	157½

RAINFALL AT YERKES OBSERVATORY.

Month	1916		Mean for Decade		Gain 1916	
	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
July	0.11	2.8	3.81	96.8	−3.70	− 94.0
August	2.48	63.0	4.72	119.9	−1.24	− 31.5
September	3.92	99.6	3.56	90.4	+0.36	+ 9.1
Total	6.51	165.4	12.09	307.1	−4.58	−116.4

The Damping of Waves and other Disturbances in Mercury.— Mr. M. H. Stillman, assistant physicist in the U. S. Bureau of Standards finds that the trembling of a Mercury surface can be partially eliminated by means of a strong magnetic field properly arranged about the containing vessel. The discussion of his experiments is given in the "Scientific Papers of the Bureau of Standards" No. 289.

Biographical Memoir of George William Hill.—A very satisfactory biographical memoir of George W. Hill was presented to the National Academy of Sciences, at its annual meeting in 1915, by Ernest W. Brown, and has been published by the Academy as a part of Biographical Memoirs Volume VIII. This should be read with interest by every astronomer, and especially by students who are looking forward to work in theoretical astronomy.

Appropriation for Astronomical Work.—At its meeting on October 11, the Rumford Committee of the American Academy of Arts and Sciences appropriated the sum of $300 to Professor J. A. Parkhurst, of the Yerkes Observatory, in aid of his investigation on the determination of the photovisual scale of stellar magnitudes. *Science*, October 20, 1916.

Note on a New Double Star.—The following pair was found 1916 September17 with the 12-inch Brashear refractor of the Yerkes Observatory, by the aid of which the appended micrometrical measures (made on September 17 and 21) were secured:—

B.D. $+40^\circ$ 3309($9^m.4$), 1855.0 α $18^h\,7^m\,21^s.2$, $\delta + 40^\circ\,12'.3$.

	°	″	m m
1916.713	151.8	1.31	10.0......10.7
1916.724	153.9	1.45	9.8......10.4
1916.72	152.8	1.38	9.9......10.6

The colors of the components, which form a very neat and pretty little pair are respectively white and pale blue. The magnitude estimates of September 21 are probably the more reliable of the two sets. The powers employed in obtaining the foregoing measures were approximately 270 and 488 diameters (only the former, on the second night).

I wish to express my obligations to Professor Edwin B. Frost, Director of the Yerkes Observatory, who permitted me the use of the 12-inch telescope, and to Professor Eric Doolittle, Director of the Flower Observatory of the University of Pennsylvania, for kindly looking up this star and informing me that it is new.

FREDERICK C. LEONARD.

1338 Madison Park, Chicago, Ill.
1916 September 28.

The Stars in the Daytime.—In the *Scientific American* for September, 1916, Messrs Gustave Michaud and J. Fid. Tristán of San Josê, Costa Rica, suggests that stars might be printed on photographic plates in broad daylight if an equatorial were provided with an infra-red filter and plates sensitized with the alizarin blue, silver nitrate and ammonia process were used. The scattering of light by the atmosphere decreases rapidly as the wave length of light increases, and in the invisible infra-red is practically nil. If, instead of losing rapidly in sensitiveness from the greenish yellow down to the extreme red, the human eye were sensitive to the infra-red radiations, and only to them, many stars would shine for us in broad daylight on what would then appear to us an absolutely black sky.

Maria Mitchell Memorial Fellowship at Harvard Observatory. This Astronomical Fellowship of $500 is offered to a woman for the year beginning September 15, 1917.

A competitive examination will not be held. The candidate must present evidence of qualifications under the following heads:

1. A letter from the candidate addressed to the Secretary of the Committee, giving an account of previous educational opportunities and training, and of plans for future work.
2. College diploma or a certificate from the registrar of her college, and if she has already held a position as instructor or teacher in any college or other institution, a clear statement of the work done, together with a certificate as to the quality of work.

3. Examples of work already accomplished.
4. Testimonials as to ability and character.
5. Satisfactory evidence of thoroughly good health.

The fellowship at all times must be used for purposes of serious study, and the fellow should be as free as possible from other responsibilities.

Application for the year beginning September 15, 1917, should be made under the above heads, and must be in the hands of the Secretary of the Committee Mrs. Charles S. Hinchman, 3635 Chestnut Street, Philadelphia, Pennsylvania, on or before April 1, 1917.

Committee
Prof. Mary W. Whitney, Director Emeritus of Vassar College Observatory, *Honorary Chairman.*
Annie J. Cannon, A. M. Curator of Astronomical Photographs, Harvard College Observatory, *Chairman.*
Prof. Edward C. Pickering, Sc. D., Director of Harvard College Observatory.
Prof. Anne S. Young, Ph. D. Director of Mt. Holyoke Observatory.
Prof. John C. Duncan, Ph. D. Director of Whitin Observatory, Wellesley, Mass.
Elizabeth R. Coffin, A. B., Vassar College, 1870, Nantucket, Mass.
Florence M. Cushing, A. B., Vassar College, 1874, Boston.
Lydia S. Hinchman, *Secretary*, 3635 Chestnut Street, Philadelphia.

Astronomical Anecdotes.—Occasionally we read some amusing astronomical anecdote which pleases us. Two such anecdotes were read recently by me, in the October number of *l'Astronomie.* It may be that they will be as amusing to some of the readers of Popular Astronomy. Translated into English:

"My riding teacher told me the following incident: one evening he was pointing out to his wife the light shining on board of an aeroplane. 'Oh! Oh!' said suddenly Mme Robert, 'it is going to pass very near to the star that is there—ah! It passes *behind* it!' " (Contributed by M. Houdard).

"An examiner for the bachelor's degree is questioning a candidate in mathematics. He asks him: 'Do you know what Saturn has in particular?' No reply. 'You have never heard it said that Saturn has a ring?' 'No, sir.' 'Well then, behold', concludes the examiner, astounded, 'Saturn has a ring' "! (Contributed by M. Danjon.)

Charles Nevers Holmes.

41 Arlington St.
Newton, Mass.

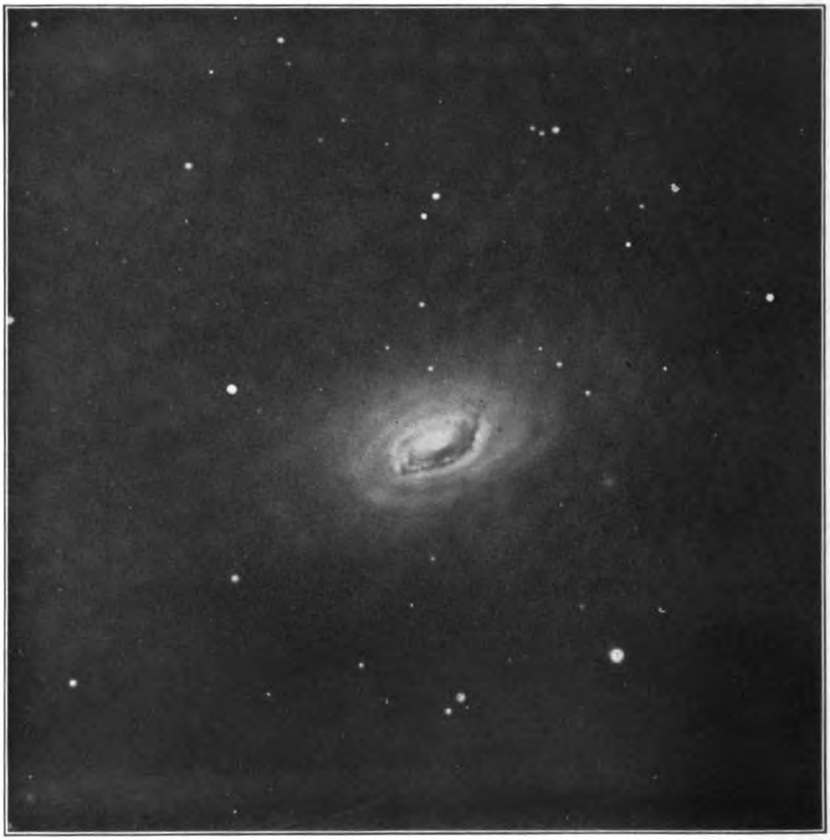
Lowell Collection on View at Roger Williams Park Museum.—A total of 1348 people visited the Roger Williams Park Museum yesterday afternoon to see the photographs of Astronomical phenomena comprising the collection of Dr. Percival Lowell, director of the Lowell Observatory at Flagstaff, Ar.

Professor C. H. Currier of Brown University was at the museum all afternoon answering questions with regard to the 150 transparencies. The people seemed much interested in the exhibit, which was opened for the first time. It will be available to the public for several weeks. The photographs are on glass and are placed in a darkened room mounted in frames with powerful electric lamps behind them. They stand out in clear relief, delicate details being much more clearly shown than in those reproduced on paper.

The collection, probably the finest one of its kind in the world, was originally arranged for exhibition in the Boston Public Library. It has also been shown in the American Museum of Natural History in New York and at Princeton and Vassar Colleges.

From the Providence (R. I.) "Evening Bulletin" of Oct. 9, 1916.

PLATE XXXIX



THE SPIRAL NEBULA M64, COMAE BERENICES

N. G. C. 4826 α(1900) $12^{h}\ 51^{m}\ 49^{s}$ $\delta + 22^{\circ}\ 13'.9$
From a negative taken with the Crossley Reflector at the Lick Observatory.

Popular Astronomy.

Vol. XXIV, No. 10. DECEMBER, 1916. Whole No. 240

THE PROBLEMS OF THE NEBULAE.*

VINCENT FRANCIS.

Nebulae are celestial bodies whose history dates almost entirely from the advent of the telescope. In fact there was only one, the Great Nebula of Andromeda, that was known to Ancient astronomers, who saw only a faint patch of light scarcely visible to the average eye. But when Galileo turned his instrument on the constellation of Orion, he discovered that the middle star of the sword also appeared like a cloud (nebula being the Latin word for cloud), and from that time on more and more have been discovered as the size of the telescopes increased, until at present there are several thousand known and catalogued. The Herschels, father and son, contributed greatly to the number of known nebulae. When Sir William Herschel first started a survey of the heavens in the hope of discovering more of these objects, scarcely more than 100 nebulae and star clusters were known, and when, years later, Sir John Herschel compiled his famous catalogue, he was able to state the positions of several thousand, a very small fraction of which were not discovered by either his father or himself.

As the increased size of the instruments used made it possible to see more and more detail, a good many of the so-called nebulae were resolved into separate stars, which, with many additions, are known as star clusters. Therefore it was only natural to suppose that all the nebulae would eventually be resolved; so when, in the year 1864, Sir William Huggins turned his spectroscope on a nebula in the constellation Draco and found to his surprise and delight that it was composed, not of individual stars, but of glowing gas with no stars at all, it created a mild sensation in astronomical circles. But this discovery, great as it was, only served to put astronomers further from the solution of the problem than before, for it was soon found that comparatively few of the unresolvable nebulae were composed of glowing gas, and that the great majority showed spectra similar to the stars.

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* Read before the New Bedford Astronomical Society on April 9, 1914.

It was then seen that nebulae were not all alike, but were divided into different classes, those composed entirely of glowing gas, and those composed of solid particles. Of these, the gaseous are sometimes called the green nebulae, the Great Nebula of Orion being an example, and the solid the white nebulae, the Great Nebula of Andromeda representing this class. A great majority of the white nebulae and, in fact, a great majority of all the nebulae were found by Professor Keeler in 1899 to have a spiral form and they are called spiral nebulae. The rest of the white nebulae, of which there are but a few, are called planetary or ring nebulae; indeed the belief is held by some that these will eventually turn out to be spiral.

The spectra of nebulae, as stated before, are divided into two classes, solid and gaseous. As we all know, the solar spectrum is a continuous band of light running from the red at one end to the violet at the other. If considerable dispersion is used in forming the spectrum, countless very narrow dark lines will be seen crossing it throughout its entire length. It has been discovered that the spectra shown by metals and other substances heated to incandescence in the laboratory show lines, many groups of which are identical with those of the solar spectrum, thus revealing to us with a few small exceptions, the entire composition of the sun.

It has also been shown in the laboratory that glowing gases under low pressure show spectra just the negative of the continuous spectrum, i. e. the spectra are dark except where the lines cross, and these lines, instead of being dark, are bright. This class of spectrum is known as the bright line or flash spectrum.

Now when the spectra of nebulae were first taken, some were found to be continuous and others showed the bright line form, thus proving that the former were composed of solid particles and the latter of incandescent gas under low pressure.

In examining the spectra of a great number of stars, it has been found that the lines are not always in exactly the same position, but are slightly displaced, sometimes toward the red end and sometimes toward the violet, and in this way the radial motions or motions in the line of sight, and velocities of practically all the brighter stars have been found, displacement toward the red meaning that the star is receding from us, and toward the violet, approaching us.

On account of the spectrographical faintness of nebulae, it has been very difficult to obtain a satisfactory figure for the motions of any of them, as the lines in the spectra are too diffuse to detect any displacement. During September, November and December, 1912, however, Dr. V. M. Slipher of the Lowell Observatory at Flagstaff, Arizona, using a specially constructed spectrograph, and making very long exposures on the Andromeda Nebula, found, taking the average of four plates, that this object was approaching the earth at the surprisingly high rate of 300 kilometers per second, this being the greatest celestial velocity hitherto observed. Since then Dr. Slipher has found certain nebulae with velocities of over 1000 kilometers a second.

On account of the diffuse appearance of nebulae it has been very difficult to obtain a parallax, not a single one showing the least signs of any. They are, therefore, conceded to be extremely remote from the solar system. Indeed no definite proper motion or motion at right angles to the line of sight, has been discovered for any of them.

In studying the location of the nebulae in the universe, it has been discovered that the farther away one gets from the Milky Way, the more numerous become the spiral nebulae, until a maximum is reached in the vicinity of the galactic poles. This, however, is not true of the other types, as they are practically all in or near the Milky Way.

In recent work by Professor A. E. Fath of Smith Observatory, Beloit, Wisconsin, he has calculated from 139 regions photographed, each a little less than two square degrees in area, that the average number of nebulae visible in the largest telescopes for each such area is 7.4, and that, as it would take nearly 22,000 such regions to cover the entire heavens, the number visible on photographs taken by the largest instruments, would be about 162,000. Incidentally, in the above mentioned 139 regions, 864 new nebulae were discovered.

Of the well known nebulae, two stand out far and away above the rest, the Great Nebula of Orion and the Great Nebula of Andromeda. The Great Nebula of Orion, although known from remote antiquity as a star of about the fourth magnitude in the sword of Orion, was not really discovered as a nebula until Galileo turned his famous telescope upon it. It is by far the greatest in the heavens, the central part covering an area larger than that of the full moon, and the outer extensions reaching several degrees in length. As stated before, this nebula, as well as all the others, is at an enormous distance from the sun, so great, some astronomers think, that the sun, together with his nearest neighbor in space, Alpha Centauri, would be deeply engulfed in the central condensation, less than a degree in area, and that its tentacles would even reach to the Pole Star, a distance of 44 light years.

If this great object were anything like as dense even as our atmosphere, its enormous weight would perturb the entire universe and its effects would be felt at the remotest confines. As nothing like such a condition exists, it must be infinitely less dense than any vacuum that can be made on earth to cover this enormous area.

The question has been raised as to how a gas so inconceivably diffuse as this and exposed to the absolute cold of interstellar space, (more than 400 degrees below zero, Fahrenheit) can be self luminous. It has been shown in the laboratory that "a small quantity of hydrogen can be enclosed in a tube and excited by an electric discharge so that it emits light of the same kind as that which comes to us from the hydrogen in a nebula." It is not possible, however, that the conditions existing with the hydrogen in the tube and those existing in the nebulae even remotely resemble each other, but this is the best attempt that has been made at solving the problem.

Second to none but the Great Nebula of Orion is the Great Nebula of Andromeda. This, unlike the former, is of the white type, and has lately been shown to be spiral in form. As proved by its spectrum, this nebula must be made up of solid particles, but as rifts appear throughout it, such a great body as this must be made up of excessively minute and very diffuse dust particles, otherwise it would be as opaque as a wall and would be of such enormous weight as to disturb the whole universe.

As stated before, this nebula was known to the ancients as a hazy patch in the sky, but was always a puzzle until the increasing power of telescopes and the advent of the spectroscope showed it in its true light.

With the advent of high power telescopes, and more recently photography, into the study of the heavens, not only were the hazy stars found to be star clusters and nebulae, but whole regions of the sky, which apparently were just as clear and in which the stars shone just as sharply, were found to be more or less covered with nebulous matter. Thus it was found that practically the whole constellation of Orion was "a region affected with nebulosity," to quote Sir William Herschel. Also the Pleiades appeared covered with nebulosity on photographs of very long exposure.

It is also thought that regions like those just mentioned are covered with invisible or dark nebulae, as in certain sections mostly in the Milky Way, the light appears to be cut off or as if some absorbing medium intervened. There is one particularly striking example in the constellation of Sagittarius which "appears as a small oval patch about one-half the apparent diameter of the moon, in the middle of a dense star-cloud. Instead of looking sharply black like other portions of the sky, this spot seems dull, and at times a faint luminosity has been thought to be present, thus indicating an absorbing medium. The one or two small stars appearing in this dark space are thought to be this side of it.

In connection with the absorption of light in space, experiments are now partly completed which tend to show that the spectra of very remote stars show a marked absorption in the violet end compared with stars of the same spectral type, but known by determinations of parallax to be comparatively near us, thus making the former appear redder just as the sun looks redder when setting than at noon, owing to the greater extent of atmosphere through which we see it when near the horizon with the consequent absorption of the blue and violet light.

Speaking of dark nebulae, it is now thought that the nebulosity surrounding the stars in the Pleiades is really dark and shines by light reflected from the stars of this cluster, as the spectra of both appear to be identical.

Another proof of the existence of dark nebulae is the nebula surrounding Nova Persei, "the new star of the new century." This extraordinary star was discovered in February, 1901. In a few days it increased in brightness from invisibility to the brightest star in the northern hemisphere. After reaching its maximum brightness on February 24, it began to wane slowly and irregularly until in August it was of only the sixth or seventh magnitude and invisible to the naked eye. On September 20, Professor G. W. Ritchey of the Yerkes Observatory in Chicago photographed the star with an exposure of four hours. Early in September there had been no trace of nebulosity surrounding it, even when observed through the 40″ telescope of the same observatory, but on this photograph there appeared two wisps extending toward the west and curving toward the north and looking like the faint traces of a spiral nebula. In November, not only a well formed spiral was seen, but the nebula had increased in size at the alarming rate of eleven minutes of arc in a year.

It was impossible to believe that matter from the star had traveled at such a rate from it no matter how great the force behind it, so the natural solution of the problem was to suppose that a dark sun had run into a dark nebula, the intense heat caused by the contact making the star blaze forth in all its splendor, and then, as its light traveled from the source, it illuminated the nebula, causing it to shine by reflected light.

As the light advanced at the rate of eleven minutes of arc a year, as stated before, the distance at which this object must be is at least 300 light years, that is to say that the catastrophe occurred and its light started toward us at the rate of 186,000 miles a second, at about the time that Galileo first pointed his telescope at the heavens, and that in seven months time, it was lighted up in all directions so that its length and breadth would each be equal to about one third the distance from the sun to his nearest neighbor, Alpha Centauri.

There have been several theories advanced as to what part the nebulae play in the formation of suns, planets, or groups of stars, the most famous being the Nebular Hypothesis originated by the great French mathematician and astronomer Laplace.

This theory takes our own solar system as an example. It commences with the idea that the matter which formed the sun after the initial catastrophe was spread out like a disc or round nebula and reaching to the farthest limits of the solar system, presumably at that time to the orbit of Uranus, Neptune having not yet been discovered. At this stage it was perfectly stationary, not revolving on its own axis, but the gravitation of all its particles toward the center caused it to shrink, this creating crowding and collisions which caused it to revolve ever so slowly at first.

As the density became greater and greater, the revolution became faster and faster until a time came when the centrifugal force became so great that a ring was thrown off. When the mass had contracted still further, another ring left the sun, and then another and another until a ring had been left to form each planet.

Collisions among the particles forming the rings caused knots or bunches to be formed, these knots reaching after a time such a size that the rings broke up into several condensations, the condensations of each ring revolving in approximately the same orbit. Finally the attraction of these condensations for one another and the slight differences in their periods of revolution, caused them to come together, and thus we have our eight planets (at that time seven) from eight rings left by the sun at the time its diameter equalled the diameter of the different planets' orbits. In the case of the asteroids, it was supposed that the ring from which a planet would have been formed at this distance from the sun, after breaking up, was not allowed to come together into one body owing to the perturbing action of the giant planet Jupiter, and that its particles, only a few at that time, must forever remain separate.

This theory was advanced nearly a hundred years ago, and since then it has been given up by most, if not all astronomers, they for the most part thinking that while it might hold good for one particular case, it would be totally inadequate to meet the vastly larger and more difficult problems of the present day. The only objects which could in any way support this hypothesis are a few planetary and ring nebulae which appear like a ring with a central star, and the rings of the planet Saturn. However, when the Nebular Hypothesis was first put before the public, it was considered a great advance toward the solution of the problem, and Laplace deserves the greatest credit for formulating it, as nothing at all acceptible had as yet been thought of.

Another theory which has recently been evolved and which has gained a good deal of credence among astronomers is the Planetesimal Hypothesis of Professors Chamberlin and Moulton. This theory applies to spiral nebulae only. It supposes that two independent suns possibly bright or possibly molten, or gaseous at the core but with a more or less thick crust on the surface, approach very close to each other. This causes great tidal pressure on each in the line of gravitational pull, making each tend to take an ellipsoidal figure. If the crusts are very thin or there are none at all, they will assume this shape comparatively easily, but if the crusts are more or less thick, they will cause great resistance, and when the strain becomes too great on the weaker one, it will explode with great violence, "and the internal mass will leap out on the two opposite sides in great fiery spouts." These spouts, owing to the rotation of the body, will take the form of spirals and enormous amounts of matter will be scattered far and wide, what is left, after the body able to withstand the strain has gone on its way, forming the nucleus of the newly formed nebula. The matter thus thrust forth from this nucleus condenses and "finally turns into streams of solid particles circling in elliptical paths about their parent sun," these particles being the planetesimals of the theory.

As these planetesimals revolve, collisions occur, condensations are formed, grow larger, and finally form the planets.

This theory does not prove entirely satisfactory, as most of the spiral nebulae are so enormous that instead of forming planets they are undoubtedly forming mighty streams of countless suns, and that instead of the two original suns separating, if they approached close enough to each other to cause such enormous tidal outbursts, their mutual attraction, if they were anywhere near equal in size, would hold them together so tightly, that they could never again break away.

Another theory takes for its chief arguments the repulsive power of light on minute particles, or radiation, and the great majority of nebulae that are clustered about the poles of the Milky Way. It says that when suns are formed from the nebulae in this neighborhood, they are drawn by gravity toward the Milky Way on account of the vast majority of the matter of the universe in this body. The nearer they get to it, the more light they receive, thus, according to the theory of radiation, forcing minute particles away which immediately start again for the galactic poles, there to come together to form new nebulae from which new suns are made to begin their journey again.

If this theory is correct, an endless chain is constantly in process, and the life of the universe is infinite and unending.

Another theory that has lately been advanced states that rapidly rotating spirals tend to become circular, the universe being in an advanced stage of this process, having turned from a spiral into a more or less flattened circular disc bounded by the Milky Way, and that the vast number of spiral nebulae that we see are all separate universes undergoing the same transformation.

Most of the problems concerning the nebulae that the present day astronomers have before them are presented here, and as each new discovery opens up new fields, the more that one knows about these strange and wonderful objects, the more difficult becomes the problem of how they were formed, what part they play in the universe, if indeed they be in this universe, and what they will become in the almost infinite future.

107 South St.
New Bedford, Mass.

THE LUNAR CRATER LINNÉ.

JOHN A. COOK.

In POPULAR ASTRONOMY for March 1913, I reported having observed a small crescent shaped elevation in the white spot out on the floor of Serenitatis, well known by the name of Linné.

All students of our satellite are aware that this object has been more attentively observed than any other spot on the Moon's surface, as it has been believed that Linné offers better opportunities than any other region to prove that our beautiful satellite is not dead and cold to the center.

Neison, in his great work, 'The Moon', devotes several pages to this little, apparently insignificant object. W. H. Pickering in his, 'The Moon', sums up the situation far more briefly, as follows: Riccioli, in 1651 shows it as a deep crater. Schröter, in 1788, describes it as a round bright spot, with an uncertain depression. Lohrmann early in the last century, describes it as a deep crater, and more than four miles in diameter. Mädler made it six miles. Schmidt drew it eight times, and made it seven miles, in diameter and one thousand feet deep. In 1866, it disappeared for a time; after a few months it reappeared as a very small crater not more than a quarter of a mile in diameter. It increased in size until it measured one and a half mile, then it decreased until it was only three quarters of a mile, according to Professor Pickering, 'The Moon', page 39.

My observation mentioned above, when I first saw the crescent shaped elevation, was made on March 7, 1911. It was verified in other observations as to the elevation, but I never saw the crescent again.

On May 8 and July 6, 1916, observations were made under very favorable atmospheric conditions. The elevation was easy with power of 200 on the 7″ refractor. It has lost its crescent shape, is larger than when last seen, and is now a typical little mountain, like Pico, except in size. It throws a shadow larger than that in any of the small craters in the vicinity with which it may be compared.

We have it on good authority, that the white spot varies in size, being larger at sunrise than when the sun has been shining down on it for a week or ten days. This has been accounted for by Mr. Pickering, as vapor issuing from an orifice; on coming into the colder outer temperatures it is deposited as hoar frost, and partly disappears under the sun's heat. If this is true, and it is very plausible, the little mountain we have seen form is in all probability ice, rather than more durable rock, and further change may be expected. The case offers an opportunity for the world to settle the long drawn out controversy, as to whether there is any change taking place on the surface of our Satellite, other than can be accounted for by the sun's heat, which many deny.

The observation requires favorable conditions, and can only be made with any hope of success under extremely oblique light, as the elevation disappears when the white spot appears; this sometimes happens in an hour and sometimes not during the same night. The writer has watched the first rays of the sun strike the little mountain, and seen the familiar spark of light, when the surrounding sea floor was yet in the shadow, the terminator not having reached it. The elevation is not in the center of the white spot.

I have not been able to catch conditions favorable at the hour of sunset, and if there is any crater within the white spot, it is concealed by the shadow seen under the rising sun.

Macon, Mo.

CHRONOLOGY OF THE EGYPTIAN PYRAMIDS.

F. J. B. CORDEIRO.

These monuments of remote antiquity have engaged the curiosity of man from time immemorial. A host of travelers, Greek, Roman, mediæval Arabian, and modern, have examined them, measured them, pondered over them and left us their opinions. When were they built, what was their purpose, and what hidden meaning do they contain? We know very little more of these things than Herodotus did. He recognized, as we today know, that they were the tombs of great personages—ancient rulers,—but beyond that we cannot go with any certainty.

The bibliography since 1799, the year that the scholars attached to Napoleon's army of invasion founded their Egyptian Institute, is enormous. Among many of these writers the pyramids have exercised a peculiar influence, in that it has led them to form scientific or religious theories which they sought to justify through them, or has led them to attempt to fit preconceived theories to what they found there. This influence has not only left its mark upon the genus "Crank", as was to be expected, but has also attacked some of the most conservative men of science.

In 1840, an individual known as Mr. John Taylor, of Gower St. London, founded a religious sect known as the "Pyramidists," their religion being directly revealed in the Great Pyramid. There is nothing very remarkable in this, but it is remarkable that twenty years afterwards Professor Piazzi Smyth in Scotland, and the Abbé Moigno in France, became the chief prophets of this new religion. Now both of these gentlemen were conservative scientific men, logical by nature, of excellent general judgment, and trained in the strict methods of the mathematico-physical sciences. Professor Smyth was for many years Astronomer-Royal of Scotland, and a most competent and distinguished astronomer. The Abbé Moigno was the scientific associate of Leverrier and well known to mathematicians by his work. According to these gentlemen, the exact measures of all the constants of the solar system are contained in the Great Pyramid. A more exact value of the distance of the sun from the earth can be found in the Great Pyramid, than by the most refined observations and calculations, by reason of the fact that the builders put it there by "divine inspiration." The length of the polar axis, the precessional period, the sidereal day, the year, and in fact all measures are accurately recorded there.

Professor R. A. Proctor took the pains to demolish these contentions one by one, which he did most successfully and with evident delight. There have been few clearer minds than his, and it would seem unlikely that one who so readily detected a flaw in another's argument would permit an error to enter into his own. And yet it would seem that this fatal pyramid influence did not leave Professor Proctor unscathed. After saying that "It is almost impossible to mark any limits to what may be regarded as evidence of design by a coincidence-hunter," and quoting from De Morgan's "Budget of Paradoxes," he goes on to *prove* that it was the design of the builders of the Great Pyramid to place the centre of its base exactly on the thirtieth parallel of latitude. True, it is not there, but about one and one-half miles to the south of this parallel. But he adds, the reason is that they knew nothing of atmospheric refraction. Further, according to Professor Proctor, this error shows that these ancient astronomers must have used the northern stars in determining their latitude, and not the sun.

Now there are some thirty-eight other pyramids within twenty miles of the Great Pyramid on the left bank of the Nile, varying in latitude from 29° 17′ to 30° 4′. In the immediate vicinity of the Great Pyramid and *near* the Nile, there is no spot where it would be possible to raise such a structure exactly on the thirtieth parallel. For the Great Pyramid is on the extreme northern verge of the old lime stone reef which was washed by the ancient Mediterranean prior to the formation of the Nile delta. If the builders had attempted placing it farther north, and anywhere near the river, they would have to have dug through an interminable amount of Nile silt before finding bed rock.

It is evident that the first consideration was to find a suitable rock surface which could be planed down to form a platform. The particular latitude of such a platform did not matter, as is clear from the other pyramids.

The orientation of these pyramids, which all have their bases very exactly in the cardinal directions, could only have been determined by astronomical observations, and the builders were undoubtedly astronomers of a high order. We may grant much, but it seems to be unnecessary to grant more than is called for. They understood goniometry perfectly and probably could measure their angles within one minute. They could determine latitudes quite accurately, but that they knew that the earth was a globe and what its diameter is, as Professor Proctor maintains, seems doubtful. As they knew nothing of theoretical mechanics, they could not have known that the earth is compressed, and they could not have calculated the return of comets, as Diodorus Siculus credits them with having done. They probably knew nothing of the Precession of the Equinoxes, although it is barely possible that they might have detected this through careful and long-recorded observations, just as thousands of years later Hipparchus detected it. They undoubtedly knew very accurately—within one minute—the inclination of the earth's equator to the ecliptic, or the breadth of their torrid zone.

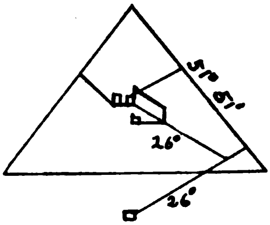


Fig. 1

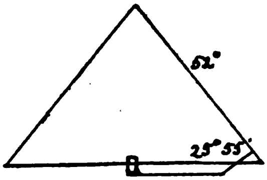


Fig. 2

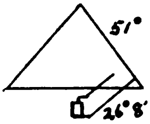


Fig. 3

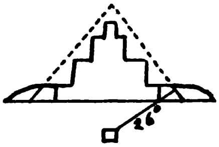


Fig. 4

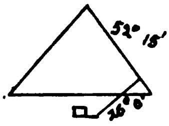


Fig. 5

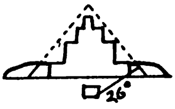


Fig. 6

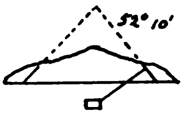


Fig. 7

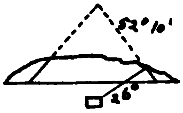


Fig. 8

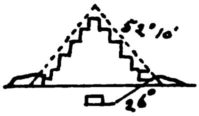


Fig. 9

PYRAMIDS AROUND GIZEH.

Meridional Sections Fig. 1 Khufu (Cheops)
Fig. 2 Cephren
Fig. 3 Menkaura

It is astonishing that all coincidences, analogies and theories have heretofore been taken solely from linear measures of the Great Pyramid, while no attention has been paid to the angles. In 1638, Professor Greaves, then professor of astronomy at Oxford and Astronomer-Royal of England, visited the Great Pyramid and made some careful measurements. He gave the inclination of the entrance passage as 26°. Angles did not enter into Professor Piazzi Smyth's scheme and all that he has to say about them is, "The angle of the rise of the Pyramid's flanks and the angle of descent and ascent of its passages are both peculiar angles, characteristic of the Great Pyramid." Professor Smyth gives the inclination of the faces of the pyramid as 51^{c} 51′, and the inclination of the descending and ascending passages as exactly alike, and 26°. These angles are not only characteristic of the Great Pyramid, as he says, but are characteristic of all the other pyramids. The only suggestion that Professor Smyth has to make in regard to this particular angle is that, provided the builders divided their circle into 1000 parts, then "The angles 26° and 52° would be, after a fashion, commensurable parts of a whole circle." The trouble is, they are not. Since at various times, before or after, there was probably a connection between the Egyptian and Babylonian astronomers, it seems likely that they divided their circle into 360 parts, but we have no knowledge on this point.

A writer in the Encyclopedia Brittanica has suggested that this particular angle was chosen because its tangent is one-half, i.e. the rise is exactly one-half of the advance. But the angle whose tangent is one-half is 26° 34′, and this is an angle which the pyramid builders could not possibly have confounded with their own peculiar angle.

The most reliable angle measurements that we have of the first nine pyramids around Gizeh, are as follows:

		Slope		Passages	
		°	′	°	′
1	Khufu (Cheops)	51	51	26	
2	Cephren	52		25	55
3	Menkaura	51		26	2
4		—		26	
5		52	15	26	
6		—		26	
7		52	10	26	
8		52	10	26	
9		52	10	26	

These angles, while in each individual case only approximate, give us as averagé values 26° and its double 52°. The sixth, seventh, eighth and ninth pyramids have crumbled down into ruinous heaps, and are probably older than the others.

Now there can be no doubt as to the reality of this pyramid angle. It is a particular and carefully selected angle, and it "sticks out" everywhere. The question naturally arises—why this particular angle, when there were so many other angles that might just as well and just as easily have been chosen? Before answering this question, let us be sure that we are not overborne by the "Pyramid Influence" which can carry away not only the plain "Crank," but an Astronomer-Royal and a genius like Professor Proctor. Let us not merely hunt for coincidences and then build up theories upon them. There are coincidences, and coincidences, and it is the province of the theory of probabilities to sift such cases.

In the first place the angles are everywhere the same, but these are not coincidences. The agreement was planned; it was not accidental. Was there any angle which would be likely to impress itself upon them and lead them to adopt it for their pyramids, as their sacred angle? Yes. There was then, and there still is, one angle and only one angle in all nature which presents itself unmistakably to mankind. This angle is the inclination of the equator to the ecliptic, or the breadth of the tropical zone. The ancient Egyptian astronomers certainly knew this angle to a minute. We need not suppose that they had any idea of the revolution of the earth about the sun, or the real reason for this seasonal wandering of the sun, for they probably had not; they simply knew the angle because they had measured it, and quite accurately at that. If two men, wholly independently of each other, are to come to me and utter some word, the chances that those words shall be the same are infinitesimal. But if they should utter the same word, out of all the possible words they might have chosen, then it approaches a certainty that there was collusion. Such a coincidence savors of conscious mental effort.

But, it may be said, the tropical angle—the angle between the equator and the ecliptic—is only 23° 27′. That is the present angle, but was it the angle at the time the pyramids were built? Decidedly not. The angle at *that* time was in all probability around 26°.

Less than 400 years ago, the general belief was that the earth did not move at all; it was supposed to be absolutely stationary. Finally the evidence became overwhelming that it must have at least two motions —a rotation and a revolution about the sun. For this view to become accepted it was necessary for the scientific men of the day to be *willing* to examine and weigh the evidence. This was for a long time an impossibility. In the next place it was necessary that they should be *able* to *understand* the nature of the question, but though the mentality required here is very moderate, there were further difficulties.

Two hundred years ago, Bradley rediscovered the Precession of the Equinoxes by observation just as Hipparchus had originally discovered it, 120 B. C., and Newton gave the reason for it. This was ignored for a long time, but finally accepted, rather upon authority than from any distinct understanding of the cause. There is still another motion of the earth which theory shows must exist, and which does exist. This is due to the elasticity of the earth and consists of a slow pendulation of the axis of the earth through the pole of the ecliptic. The earth's axis describes a small precessional circle about the pole of the ecliptic, and if the earth were *absolutely* rigid, these circles would be closed curves and the inclination would remain forever practically unchanged. But the earth is not absolutely rigid, with the result that the precessional circlings are not closed curves, but spiral gradually inward. In a very long time, therefore, the inclination of the earth's axis undergoes very considerable changes. The reader who wishes to inquire further into these motions is referred to Routh's "Rigid Dynamics," "The Gyroscope" (Spon and Chamberlain), and an article in "POPULAR ASTRONOMY," August 1915. Our data as to various inclinations of the earth's axis in the past are necessarily scant and not very reliable. Perhaps the best value we have is that of Erostosthenes (236 B. C.) who found it between 23° 52′ and 23° 51′. Hipparchus (120 B. C.) is said to have found it 23° 51′.

Taking this value, it will be necessary to go back to about 10,000 B. C. before the inclination is 26°. Using Ptolemy's (130 A. D.) determination, which is in all probability erroneous, the date would be 6370 B. C. The estimates of the time of the pyramids vary widely—all the way from 3000 B. C. to 13,000 B. C., and even more. The simple fact is, we do not know when they were built.

If, however, the angle 26° represents the natural angle at the time they were built, then we have some definite land marks in our chronology. In that case we have a permanent record of the inclination of the earth's axis at some time in remote antiquity, and knowing the rate we might find the time, and vice versa.

It is, of course, possible that the angle 26° marks only the era when pyramids first began to be built, and that afterwards this angle was slavishly and religiously copied. In this case, the angle would lose its value as a chronological factor. But it seems more probable that the builders who were able to determine the angle were also able to revise, and did revise it, from time to time. Possibly the slightly greater angle in the older pyramids—seventh to ninth—points to a greater age by some six to seven hundred years.

The pyramid builders selected a peculiar angle—in the neighborhood of 26°, and its double 52°—which they put into all their structures. They were astronomers and geometers of a high order, as their mathematical structures prove. That they should have selected as their standard pyramid angle, the breadth of their then tropical zone, seems natural, as it was and still is, the only definite angle presenting itself in nature. It is practically certain that the inclination of the earth's axis had this value about 10,000 B. C. There is a strong presumption, therefore, that the pyramid angle represents the great angle of nature. With less certainty, we can infer that the pyramids were built some time between 11,000 B. C. and 6000 B. C.

THE MOTION OF THE POLE.

O. H. TRUMAN.

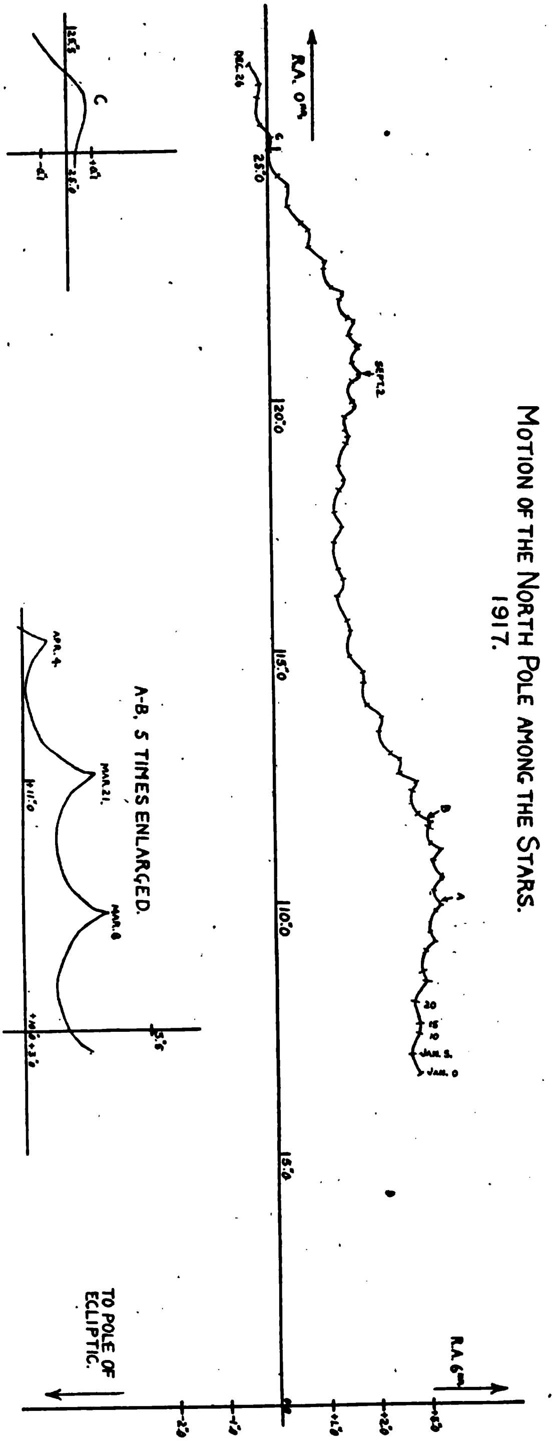
All text books on astronomy give a description of the phenomona of precession and nutation, but never have I seen the last represented by a proper figure—a figure which shows what actually happens instead of an idealized version, and is calculated to give the student a correct and definite idea of it. In an endeavor to present the subject in a more correct and at the same time a more appealing way than common, therefore, I have made for our University a lantern slide from the accompanying drawing, which will be used in conjunction with another slide showing the conventional representation of the precessional circle among the stars. An illustration of the latter is to be found in many astronomical works, for instance, in Young's Manual of Astronomy, p. 146, and is doubtless familiar or accessible to the reader.

The large circle on that drawing represents the 25,000 year path of the pole of the equator about the pole of the ecliptic, and this path would be exactly followed, at a uniform rate, if the force were uniform which tends to tip the earth's axis so as to make the equator coincide with the ecliptic.

Now it is well known that this force is due to the attraction of the sun and moon on the equatorial bulge of the earth, and if the sun and moon were always in the same positions with respect to the earth, and always the same distance from it, we should in fact have a constant force and a uniform precession.

But this is not the case. Twice each year the sun is on the equator, and its tipping force upon the earth is reduced to zero; twice each month the same is true of the moon. Moreover, once every nineteen years the plane of the moon's orbit is at a maximum inclination to the plane of the equator, the average distance of the moon from that plane is great, and its tipping effect correspondingly increased, while at intermediate intervals, because of the revolution of the moon's nodes, the reverse is true. And added to all of this, the distances of the moon and sun from us vary by important amounts.

So the twisting force upon the earth is very irregular, and the pole, instead of moving at a uniform rate along the precessional circle, moves at a variable speed, and departs a little from the circle, sometimes toward, sometimes away from, the center. When the whole matter is submitted to analysis, it turns out that, something as we avoid the irregular motion of the sun in time-keeping by the device of an imagin-



MOTION OF THE NORTH POLE AMONG THE STARS.
1917.

ary sun thought of as moving uniformly along the equator, so here we can think of a mean pole moving exactly along the circle at the average rate of the true pole, and find the place of the latter by applying small corrections to the place of the former. The motion of the mean pole is what is commonly spoken of as precession; the motion of the true pole with respect to the mean pole is nutation.

It is possible to compute the nutation by means of the Besselian star numbers in the *Nautical Almanac.* I have done this for intervals of five days thrughout the year 1917, and plotted the results in the largest of the annexed drawings. The *X* axis, 25″ or more long, is a very small section of the circular path of the mean pole; and, of course, being a very small section of a circle, it looks like a straight line. The intersection of the two axes, 0.0, is the point occupied by the mean pole at the beginning of the year, January 0.217 da., and the curve shows the motion of the real pole and its position for various dates. When the curve is above the axis, as it is for most of its length, the pole is outside the precessional circle. The marks across the curve are at five day intervals.

The first thing to be noticed is that the curve descends, on the whole, throughout the year. This is the effect of the long nineteen year irregularity due to the motion of the moon's nodes. The pole has been outside the circle for nine and a half years, at most by nearly 10″.0, and is just crossing the circle to go the same distance inside. The pole, moreover, is far ahead of its mean place, but at the end of the year will commence to fall back, and in four and three-fourths years will be overtaken by the mean pole. Thereafter it will remain behind the latter for nine and one-half years, then come ahead of it again, and so on.

Next there is apparent another fluctuation, coming to maxima about March 8 and September 2, times half a year apart. This is due to the sun finding itself furthest from the equator, and so able to exert the most force, twice a year, and upon the equator, and so powerless, twice.

Then there is a still smaller variation, with a period of a month, for the moon suffers fluctuations in its power the same as the sun, and for similar reasons, only twelve times as rapidly. The variations due to the changing distances of the sun and moon from us are too small to be noticeable in the drawing.

Last of all, the great irregularity of motion along the curve is to be noted, for while the pole usually makes good progress, sometimes during an interval of five days it scarcely moves at all.

In order to show the different character of the curve at different times, I have drawn two small portions of it, each enlarged five fold. During March it has little sharply pointed peaks, but by the end of the year these are rounded off, as at C. I did not, of course, attempt to show the form of the main curve with such minuteness.

Had there been any stars near the pole's path I should have marked them, but none, even as faint as seventeenth magnitude, are close enough to show. But after all this is not surprising, for if one should put on his telescope an eyepiece having a field less than half a minute in diameter, and point at random on the sky, what would be his chance of seeing a star? The entire year's path of the pole is comprised in a space but little larger than the trapezium of Orion, and the minuter variations which I have drawn are so small that if traced upon the sky they could scarcely be seen, even with the greatest telescopes. But from the eye of mathematics they do not escape. It sees them and predicts their coming years into the future, and determines the allowance that must be made for them in those minuter observations where alone they are able to make their presence felt.

University of Iowa.
Sept. 29, 1916.

POLARIS.

CHARLES NEVERS HOLMES.

Where Cepheus reigns weakly in the sky
And Draco yawns with widely open jaws,
Where Ursa Major circles low and high
Propelled by power of celestial laws;
Where Ursa Minor daily, nightly, turns
Around a sky-set axis of man's Home,
Polaris like supernal beacon burns,
A pivot-gem amid our star-lit Dome.

Amid the darkness, the silence of evening a star-gazer stands shadowless beneath suns almost incomparable in their remoteness. No cloud, no moon, no planet shining brightly. No electric light, no lamp in a window, no sudden gleaming ray as some automobile passes swiftly. Darkness on all sides, darkness everywhere except far, far overhead, in the firmament sparkling with jewels of fire. Underfoot the winter's snow, almost invisible beneath night's shroud; spotless snow as yet scarcely trodden by man. A frigid night, so dry and stimulating that the cold is hardly felt; and there are health and vigor in each indrawn breath. Many miles from the glare and glitter of a large city, yet not far from homes hidden by knolls and woods. Quiet almost as a tomb, silent almost as in some aeroplane floating in space. Not even the warning bark of a dog from a distance, a condition of perfect terrestrial peace and tranquility. And overhead the stars!

From earthly darkness to celestial light, from silence and solitude to sun and satellite expressing titanic energy and sidereal association. An ensemble of firmamental splendor that presses upon a star-gazer as softly as some spider's web and yet as stupendously as an overhanging avalanche. Safe indeed feels a student of astronomy, surveying calmly with his small or large telescope the myriad suns framed by the Milky Way. Safe indeed!—amid the architecture of a Builder whose invisible laws are perfect, whose Hand holds like some gigantic vise the fiery star or the shining satellite. Safe in the midst of moving planets which are revolving rapidly like so many ponderous wheels in the illimitable factory of a universe. Atomic man, groping blindly afar from his terrestrial home, accumulating bit by bit astronomical knowledge more priceless than earthly jewel or gold. And presently, slowly, this shining ensemble of the firmament seems to fade before the eyes of a star-gazer amid a wilderness of snow, where all is dark and silent, and he gazes long and earnestly upon one sun, an inconspicuous sun, twinkling quietly to the northward.

It is Polaris—Polaris of Ursa Minor—Alpha Ursae Minoris! Truly it is not a conspicuous star, particularly when winter's glorious galaxy sparkles so splendidly in the south. *There* are Capella, Aldebaran, Rigel, and—most spectacular of all—brilliant Sirius. Certainly Polaris appears very, very insignificant when contrasted with any of these first-magnitude sky-gems, and to those of us inexperienced in astronomical science this chief sun of the constellation Ursa Minor seems hardly worth more than a momentary glance. But to those who are experienced in sidereal research, and indeed to anyone who remembers what he has read about the North Star, this inconspicuous sun is of great importance, despite its inferior appearance. Indeed, most of us have heard or read something concerning Polaris, and some of us have tried more or less successfully to discover its whereabouts. Not a few otherwise well-informed individuals are in doubt respecting the exact position of Alpha of the Lesser Bear, although they are very certain that the Dipper has something to do with finding its position. And it is true that some of us after discovering the Dipper and even its "pointers" are still unable without assistance to see the North Star. So unaccustomed are they to the starry skies, where almost every sun looks alike to them, that ofttimes an experienced star-student has some difficulty in "showing" Polaris to an inexperienced star-gazer who will perhaps not believe at first that such a small, twinkling firmamental object is really the famous North Star.

But an experienced sky-student standing beneath cloudless, moonless, darkened heavens, will not have the slightest trouble in finding Polaris. It is the time of night and of year when the Dipper must be in the northeast, and *there* it is! Anyone can soon find the Dipper's curving "handle", the end star of which is named "Benetnasch", and, following that handle from Benetnasch through to the other end of the Dipper, we pass in all seven stars; Benetnasch, Mizar, Alioth, Megrez, Phecda, Merak and Dubhe. Now, Merak and Dubhe, the two suns farthest from Benetnasch, are the famous, so-called "pointers", and an imaginary line drawn from Merak to Dubhe and extended northwestward, or whatever direction the Dipper's location requires, will come near the North Star. The "pointers" do not aim directly at Polaris, and that sun is a little way firmamentally from Dubhe; but the North-Star is the most noticeable sun which the imaginary line first passes, and even an inexperienced sky-student should not have great difficulty in finding Polaris if he "sights" accurately from Merak and Dubhe.

The constellation of Ursa Minor! The so-called Dipper forms part of the constellation Ursa Major, the Greater Bear, and Ursa Minor reminds us somewhat of a smaller Dipper. It is, however, a poor, dim imitation of the Great Dipper, as well as an equally poor imitation of a sky-bear, Nevertheless, we have been accustomed for many centuries to call it the "Lesser Bear" and perhaps that name is as suited to it as any other. There are, as in the case of the Great Dipper, seven suns in the Small Dipper; Polaris being the end star in its handle and the other stars being in respective succession, Delta, Epsilon, Zeta, Eta, Gamma and Beta. Of course, the North Star is Ursa Minor's most noticeable sky-gem but Gamma and Beta are also rather noticeable, being often called the "Guardians of the Pole." In a way Gamma and Beta of Ursa Minor resemble Beta and Alpha of Ursa Major for these first two suns point rather indefinitely during evenings of January in the direction of incomparable Sirius and also towards blue Vega. But although Gamma and Kochab of the Lesser Bear attract somewhat the attention of star-gazers by their twin-like appearance close to the inconspicuous constellation of Draco, the constellation Ursa Minor would be in the same neglected class as Draco, the Dragon, were it not for the sun twinkling at the very end of its handle—Polaris the North Star.

Polaris is called the "Pole Star" yet it is not exactly at the Pole. At this point a few words should be inserted in explanation of the term "Pole". There are, of course, two of these celestial Poles, northern and southern; but we speak usually of our own northern Sky-Pole merely as the Pole, since the southern Sky-Pole's position—a position not marked by any noticeable star like Polaris—cannot be seen by us in these latitudes. Now naturally we think of the Pole as something up north, some point on our Earth's surface which so many brave men have died in trying to reach. That is what is known as the north geographical pole; but it is not the northern Sky-Pole. This north Celestial Pole is a stationary, invisible point in the heavens, just as many degrees below the zenith as is our latitude below the terrestrial north pole. In other words, were we exactly at the north geographical pole, this northern Sky-Pole would be precisely overhead. That is, just as though the Earth's axis, emerging from the top of our Planet, should continue into the immensity of outside space until it reaches Polaris. At present we are fortunate in having a typical second magnitude sun to mark the approximate position of our Celestial Pole. As we leave the north terrestrial pole, however, and descend towards the equator, the apparent firmamental place of Polaris changes from the zenith until at the equator Polaris would twinkle on the horizon. But Polaris has not altered in the least degree its position; our own place on the Earth's surface relative to the North Star has changed since we left the terrestrial north pole of snow and ice. The North Star's northern Sky-Pole is fixed and stationary exactly as the north Earth-Pole is stationary; the rest of our earth rotating around this terrestrial pole or axis. Thus, Polaris, our own northern Pole Star, should remain apparently motionless; but such is not quite the case for Polaris is not precisely at the Sky-Pole, being about 1-1/6 degrees away from it, and, as a result, our North Star makes a constant, small revolution around and around the Celestial Pole.

But Polaris is so near the Sky-Pole that it serves as a veritable signpost towards the north. Of course if the sky happens to be overcast, this North Star would be of no value; but once seen the pilot would instantly know in which direction to steer his ship. The discovery of the compass was of greatest importance to ocean navigation, particularly on cloudy or stormy days; but whereas the magnetic waves controlling the compass are somewhat changeable, our North Star is faithful, apparently motionless in the north, occupying from year to year practically the same relative position. But even Polaris is slowly changing in its firmamental position or rather we are slowly changing from Polaris. Our terrestrial axis has a certain circular movement called precession which causes, of course, an apparent, gradual alteration in the sky-position of suns and constellations. As a result, our Celestial Pole is rotating in a kind of firmamental circle, being at present within 1-1/6 degrees of Polaris, and some 12,000 years hence it will be not far from the blue, brilliant sun Vega. So that we see in a few centuries our North Star will be no longer at the Sky-Pole, although so far as it concerns us of this generation Polaris will be our faithful North Star as long as we live.

It is interesting to relate the astronomical history of the precessional rotation of our Sky-Pole. Some 4600 years ago, about twenty-seven centuries before the beginning of the Christian Era, this circular movement of our axis caused the celestial pole to pass close by a star called Thuban, or Alpha Draconis, so that at that time all the other suns and the constellations of northern latitudes seemed to revolve around that star—Thuban was the Polaris of those days. Centuries elapsed, the north celestial pole continued its slow circle overhead, until tonight it is situated only 1-1/6 degrees from Alpha Ursae Minoris. In the centuries to come, it will leave Polaris and pass through the inconspicuous constellation Cepheus, being around 7500 A.D. not far from Alpha of Cepheus, which is at present not as noticeable a sun as Polaris. After departing from Cepheus, the Sky-Pole will approach Cygnus, coming near Delta of that constellation. About 14,000 A.D., the blue, brilliant sun Alpha of Lyra will become our pole star, although Vega's position will not be as conveniently close to our celestial pole as is Polaris of this twentieth century. Around 23,000 A.D. our northern terrestrial latitudes will have once more the present proximity of Thuban for their sky pole, and about 28,000 A. D. the celestial pole will be back again where it is tonight. In other words, it takes this pole some 26,000 years to complete its circuit, from Polaris to Polaris. But what firmamental, what terrestrial changes may occur in 260 centuries!

During this present twentieth century, however, Polaris of Ursa Minor is our North Star. Perhaps a more accurate term would be "our North Stars!" For Polaris is not a single sun, all alone in the darkened heavens. It is known as a binary star, that is, two stars sparkling so close together and associated so closely that our unassisted eyesight cannot separate them. When the telescope is turned upon such a binary star, it will be found to have a companion, which may revolve around it or both may revolve around their common center of gravity. The companion of what we know as Polaris is, of course, telescopic, being about of ninth magnitude (8.8); the brighter sun of Polaris being of about second magnitude (2.1). And, in addition, it has been discovered through the spectroscope that Polaris is a triple sun, a system of three stars, number 1 and number 2 revolving around a common center of gravity in 3-97/100 days, and also revolving around sun number 3 in about twelve years. However, we need not trouble ourselves with sun number 3; but limit ourselves to the range of our telescope. It has been said that the ninth magnitude companion can be seen with a three-inch glass, and even a telescope of a trifle less diameter might be sufficient, provided sky conditions were favorable. When, however, a star-gazer separates Polaris into its two telescopic suns, he will find that the larger sun has a yellowish hue, while the smaller, which is very inconspicuous compared with the larger star, possesses a bluish tint.

Polaris, taken as a whole or as unit, is what we know as a second magnitude star, in fact it is almost a standard second magnitude star, just as ruddy Aldebaran is almost a standard first magnitude star. Of these second magnitude sky-gems there are about 48, including the famous "pointers" of Ursa Major. Star-gazers under clear, moonless skies, should compare the noticeable sparkle of Polaris (2.1) with the very brilliant scintillation of Sirius (—1.6). By comparison, Polaris is almost invisible. Yet we should remember that Sirius is one of the nearer suns (8.7 light years) while Polaris is estimated at about 70 light years, more or less. To get an adequate idea of the brilliance and volume of Polaris, it would be necessary to view this so-called second-magnitude star from the distance of Alpha Centauri—4.3 light years. There are other interesting facts about Alpha of the Lesser Bear, such as its "proper motion" across the firmament which is about 4/100 of a second of arc per year, and its radial progress towards our earth (16 miles per second in 1889), a velocity which had decreased about one-half in 1899. It would be also very interesting to state how much of a planetary system Polaris of Ursa Minor possesses, including its three suns, its two telescopic suns, or only the largest sun; but such absolute knowledge is at present far, far beyond any information that flashes to us across the titanic abysses of interstellar space.

Amid the darkness, the silence of evening a star-gazer stands shadowless beneath suns almost incomparable in their remoteness. No cloud, no moon, no planet shining brightly. No electric light, no lamp in a window, no sudden gleaming ray as some automobile passes swiftly. Darkness on all sides, darkness everywhere except far, far overhead, in the firmament sparkling with jewels of fire. In the south incomparable Sirius is scintillating like a fiery diamond; above Sirius Orion glitters; above Orion ruddy Aldebaran and beautiful Capella. Northwardly the eye of our star-gazer roves, all seems dark and devoid of suns after the glorious galaxy in the south. But due north a smaller star twinkles, not particularly noticeable, about half-way from Capella to where blue Vega sparkles on the horizon. It is Polaris, and at once the star-gazer knows exactly the sky-directions around him. On his own planet-home, wars and rumors of wars may come, nations, dynasties rise and fall, generations pass away, he himself will die; but overhead, framed by the ebon background of star-lighted night, Polaris will glitter unextinguishably on, the pole star of his grandfathers, the north star of his grand children.

Boston, Mass.
Technology Chambers.

PLATE XL

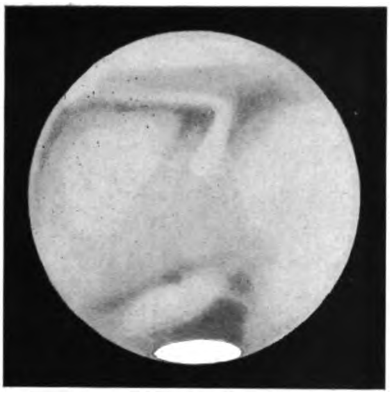


Fig. 1
Phillips
359° A

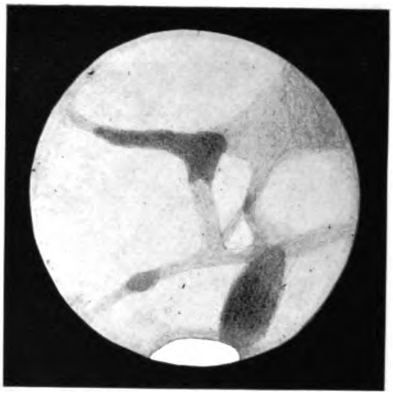


Fig. 2
Pickering
0° A

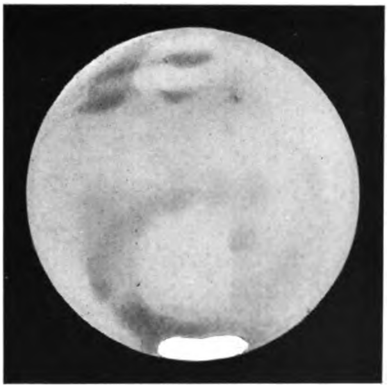


Fig. 5
Phillips
74° B

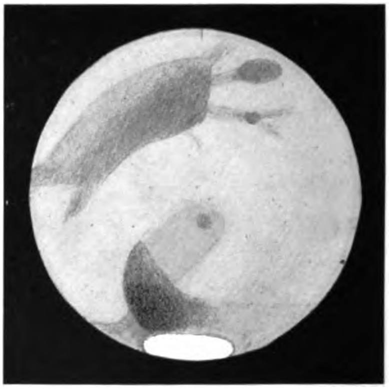


Fig. 6
Pickering
61° B

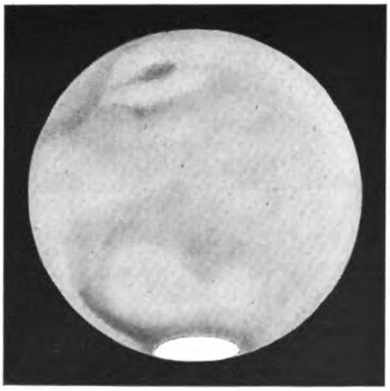


Fig. 9
Phillips
110° C

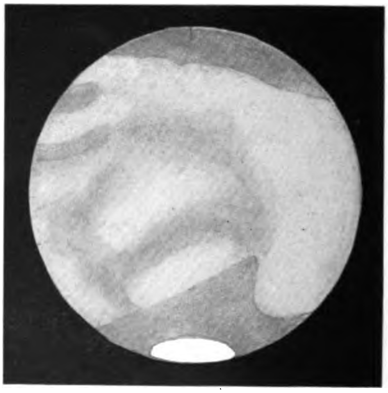


Fig. 10
Pickering
126° C

PLATE XLI

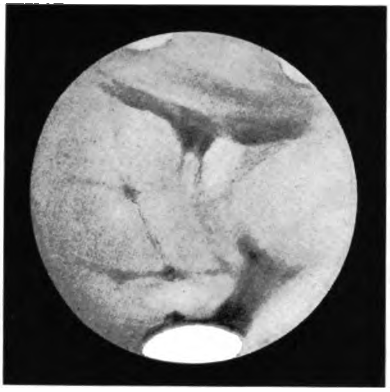


Fig. 3
Wilson
1° A

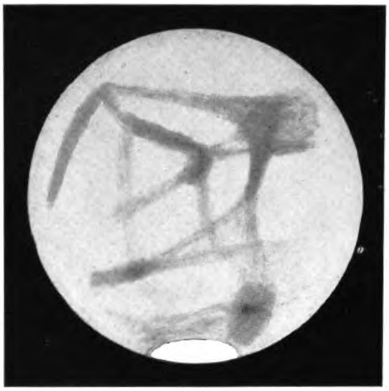


Fig. 4
Douglass
4° A

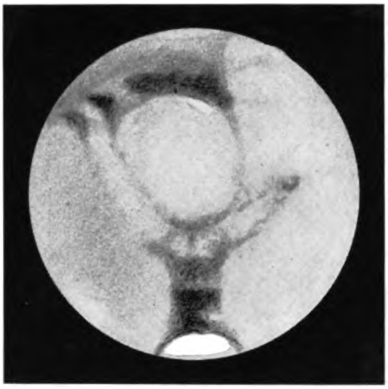


Fig. 7
Wilson
45° B

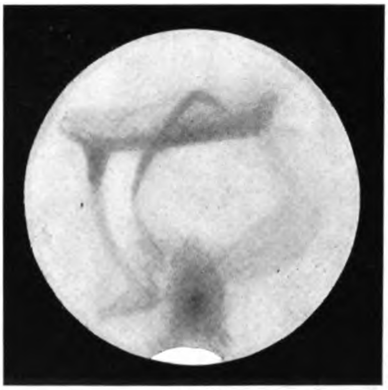


Fig. 8
Douglass
33° B

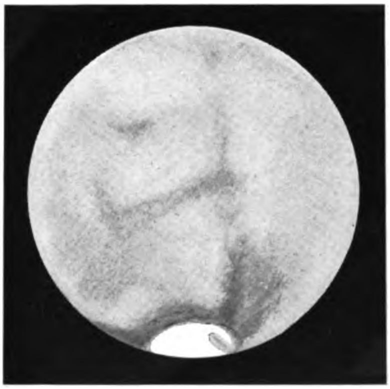


Fig. 11
Wilson
127° C

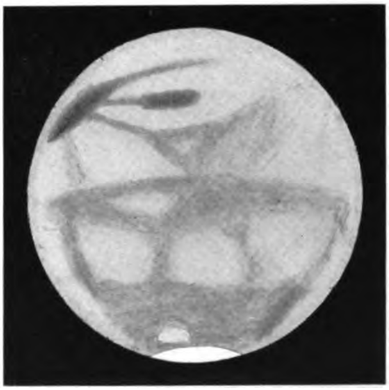


Fig. 12
Douglass
107° C

REPORT ON MARS, No. 17.

WILLIAM H. PICKERING.

THE WORK OF THE ASSOCIATED OBSERVERS OF MARS.

This organization was founded in 1913. Its object, besides general work on Mars, in part coöperative, is to obtain and publish a collection of the best drawings of the planet available, systematically arranged at each successive opposition, for the use of future astronomers. This is necessary, because the details of the surface are constantly changing, not only with its varying seasons, but also at the same season, from year to year. Well known markings constantly disappear, or shift their positions, while others previously unknown are at the same time making their appearance. By the study of these constant changes, it is hoped that future astronomers may be able to draw conclusions regarding the character of the life supported by the planet, and it is possible also that they may even gather information that will be of use to ourselves.

The scope of the Association is entirely international, and sets of drawings have been received this year from Europe, America, and the Pacific. The best six were selected, three being by European, and three by American observers. Anybody interested, and willing and able to make the drawings according to the specifications (Reports 8, 11, and 15), is invited to forward his work to the writer at the close of the coming opposition, and the best series received will be published.

The drawings here shown, like those of the previous opposition published in Report No. 8, are arranged in six horizontal rows. The upper row represents region A upon the planet, each drawing being made with meridian 0° as nearly central as practicable. The central meridians of the other regions are 60°, 120°, 180°, 240°, and 300°. Each vertical column represents the work of a single observer, and gives a complete view of the surface of the planet The previously adopted plan was to arrange these columns according to the longitude of the observers, the left hand drawings in general therefore preceding in date those that followed them. Since there are 36 drawings this year, involving six plates, it is not possible to present all six drawings of each region at a single view, as heretofore, and this plan has had therefore to be slightly modified. The observers have been divided into two groups, the first group of four employing the largest instruments, whose extreme range of aperture is nevertheless not very great, and the second group of two, the smaller ones.

The names and addresses of those whose work has been selected for publication together with their equipment, are as follows:

Rev. T. E. R. Phillips, Epsom, England. 12¼-inch reflector by Calver, and 8-inch refractor by Cooke. Magnification employed 275 to 600. Seeing on Standard Scale ranging from 6 to 10, where the higher the number, the better the seeing.

Professor W. H. Pickering, Mandeville, Jamaica. 11-inch refractor by Clark. Magnification 430 and 660. Seeing on Standard Scale ranging from 5 to 12.

L. J. Wilson, Esq., Nashville, Tennesse. 11-inch reflector made by himself. Magnification 360. Seeing 8 to 10 on Standard Scale.

Professor A. E. Douglass, Tucson, Arizona. 8-inch refractor by Clark. Magnification 350 and 450. Seeing on Standard Scale ranging from 6 to 9.

Dr. H. E. Laü, Hörsholm, Denmark. 3¾-inch refractor by Bardou. Magnification 170 and 300. Seeing on personal scale ranging from 1 to 3, where 1 is very fine, 2 good, and 3 rather bad.

H. McEwen, Esq., Glasgow, Scotland. 5-inch refractor by Wray. Magnification 160 to 200.

In Table I are given the fundamental data regarding the figures as far as they could be determined. The first seven columns require no explanation, the eighth gives the central longitude of each drawing, the ninth its difference from the proposed value, the tenth the central latitude, the eleventh the angular diameter of the planet, corrected from that given in the ephemeris, the twelfth the solar longitude as seen from the planet, and the last the corresponding Martian date as deduced from Report No 10.

In Report No. 8 we saw that the planet presented a somewhat different appearance to the observers of the Lowell Observatory from that which it did to the other three. The present six observers on the other hand, all see it very much alike. Any one of the thirty-six drawings herewith shown would be satisfactory to the writer, as indicating the general appearance under certain more or less favorable conditions. If there is any difference at all among them in the style of representation, it would appear to him as if his own drawings and those of Mr. Phillips gave the broader canals a more curving shape and the resulting appearance of the planet a less angular aspect, than is shown in some of the others. This is most marked in regions **D**, **E**, and **F**. Observers at the next opposition should endeavor to determine which of these two appearances is the more correct. Dr. Lau's drawings seem rather lacking in detail as compared with the other figures, and this is undoubtedly due to his very small aperture, only 3¾ inches, yet he shows a very considerable number of canals, as we shall see later, when we deal with the matter statistically.

TABLE I.

FUNDAMENTAL DATA OF THE FIGURES.

No.	Obs.	Aper.	Magn.	Seeing	1916	Reg.	Long.	Δ Long.	Lat.	Diam.	⊙	M.D.
1	Pl	—	—	6 (?)	Feb. 27	A	359°	− 1°	+15°	13″.2	60°.2	May 17
2	Pk	11	660,430	9, 7	Mar. 5	"	0	0	14	12.5	63.2	" 23
3	W	11	360	—	Jan. 23	"	1	+ 1	18	13.2	44.7	Apr. 38
4	D	8	450,350	7, 9	Mar. 7	"	4	+ 4	14	12.3	64.0	May 25
5	Pl	12, 8	—	8 (?)	Feb. 19	B	74	+14	15	13.6	56.5	" 8
6	Pk	11	660,430	7	Feb. 26	"	61	+ 1	15	13.2	59.7	" 16
7	W	11	360	—	Feb. 24	"	45	−15	15	13.3	58.8	" 14
8	D	8	350	6, 7	Mar. 1	"	33	−27	14	13.0	61.5	" 19
9	Pl	12, 8	—	10	Feb. 19	C	110	−10	15	13.6	56.5	" 8
10	Pk	11	430	6, 5	Feb. 24	"	126	+ 6	15	13.3	58.8	" 14
11	W	11	360	—	Feb. 16	"	127	+ 7	16	13.7	55.3	" 6
12	D	8	350	7	Feb. 26	"	107	−13	15	13.3	59.7	" 16
13	Pl	12, 8	—	7	Feb. 8	D	175	− 5	16	13.9	51.8	Apr. 54
14	Pk	11	660	10	Feb. 12	"	179	− 1	16	13.8	53.6	May 2
15	W	11	360	—	Feb. 14	"	183	+ 3	16	13.8	54.5	" 4
16	D	8	350	8	Feb. 17	"	158	−22	15	13.7	55.7	" 7
17	Pl	8	—	7	Feb. 5	E	240	0	17	13.8	50.4	Apr. 51
18	Pk	11	660	9	Feb. 7	"	242	+ 2	16	13.9	51.4	" 53
19	W	11	360	—	Feb. 10	"	250	+10	16	13.9	52.8	" 56
20	D	8	350	8	Feb. 7	"	256	+16	16	13.9	51.4	" 53
21	Pl	8	275,387	7	Jan. 22	F	315	+15	18	13.2	44.2	" 37
22	Pk	11	430	10, 12	Mar. 9	"	303	+ 3	14	12.2	65.0	May 27
23	W	11	360	—	Feb. 3	"	303	+ 3	17	13.8	49.7	Apr. 49
24	D	8	350	9	Mar. 13	"	287	−13	14	11.7	66.7	May 31
25	L	4	170,300	1	Feb. 20	A	350	−10	15	13.6	57.0	" 9
26	M	5	180	—	Feb. 20	"	4	+ 4	15	13.6	57.0	" 10
27	L	4	170,300	2, 3	Feb. 15	B	62	+ 2	16	13.8	55.0	" 5
28	M	5	200	—	Feb. 16	"	64	+ 4	16	13.7	55.5	" 6
29	L	4	170,300	1	Feb. 8	C	128	+ 8	16	13.9	51.7	Apr. 54
30	M	5	180	—	Feb. 9	"	124	+ 4	16	13.9	52.2	" 55
31	L	4	170,300	1, 2	Jan. 27	D	213	+33	18	13.5	46.6	" 43
32	M	5	160	—	Feb. 4	"	184	+ 4	17	13.8	48.1	" 50
33	L	4	170,300	2	Jan. 27	E	244	+ 4	18	13.5	46.5	" 42
34	M	5	160	—	Jan. 28	"	230	−10	17	13.5	47.0	" 44
35	L	4	170,300	1, 2	Feb. 23	F	304	+ 4	15	13.4	58.2	May 12
36	M	5	160	—	Jan. 22	"	303	+ 3	18	13.2	44.2	Apr. 37

Mr. Phillips describing his own work says that it was done under certain disadvantages, on account of the removal of his observatory from Ashtead to Headley. He had no driving clock on his reflector until after February 8. He also had a good deal of bad weather. He thinks there was considerable haze or mist in the Martian atmosphere early in the season, soon after the melting of its northern polar cap.

In speaking of the region of Nilokeras and Lunae Lacus, regions **B** and **C**, Figures 5 and 9, which he observed under unusually favorable circumstances, he says "the general appearance of this region is totally un-Lowellian in character, and the term canal altogether unsuitable." He remarks especially on the unexpected invisibility of the Ganges. On March 3 the preceding end of the polar cap was much darker than the following end. This was undoubtedly due to cloud over the former. He indicates certain cloudy regions by dotted lines in Figure 21.

The writer would point out that the clouds always lie over the so-called desert regions of the planet, apparently being precipitated as soon as the fertile regions are reached. This is clearly shown in Figure 14, where the cloud following Charontis is also indicated, half covering Elysium. This was not an unusual feature in this region in the Martian mornings, indicating doubtless that Charontis like Acidalium is composed of moist or marshy land. Incomplete canals, i.e. elongated marshes disappearing in the desert, are shown in many of the drawings, by most of the observers. Such a thing like an incomplete canal was formerly supposed not to exist. The broad hazy character of some of the early markings is clearly shown in Figure 10. These darker areas will it is expected later develop into well defined canals. In most of the Jamaica drawings the canals are still broad and curved, but in the last one secured, Figure 22, the straight narrow canals had already begun to form, and were not afterwards absent from that side of the planet.

In a letter from Mr. Wilson he speaks of the bad weather during the past winter. He also points out particularly the small projection due to cloud shown on the morning terminator of Figure 7, located over the region just following Solis Lacus. Clouds were frequently noted on the northern side of the dark regions of the planet, as in Figures 15 and 23.

Professor Douglass sends several notes relative to the clouds visible on the planet, and calls particular attention to the small white spot near the polar cap shown in Figure 12. Regarding their frequent rapid dissolution, which we have mentioned in some of our earlier reports, he notes that on February 7 at $15^h\ 45^m$ G.M.T. both sides of the Syrtis were whitish. Half an hour later only the following side remained so. This was in the early Martian morning.

Dr. Lau shows bright cloudy areas by means of dotted lines in several of his drawings, but makes no reference to them in his letter of transmission. Mr. McEwen sends a set of beautiful colored sketches in red, yellow, and violet, which it is a pity should have to be reproduced in simply black and white. Like all the other observers he shows well marked cloudy areas. But a few years ago some observers claimed that unlike the Earth, clouds were never seen on Mars, or at all events were extremely rare. During the present opposition the planet has scarcely ever been seen without them.

THE MORE IMPORTANT DIVERGENCIES OF REPRESENTATION.

It will be noticed that in Figure 3 Aryn, lying within the forked bay of Sabaeus, is represented as having appeared, to be sure rather vaguely, as early as January 23. This the writer believes is an error. To Messrs. Lau and McEwen it was invisible as late as February 20 (Fig-

PLATE XLII

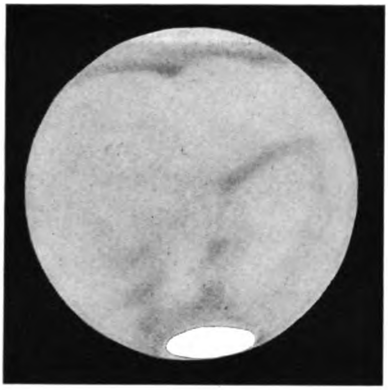


Fig. 13
Phillips
175° D

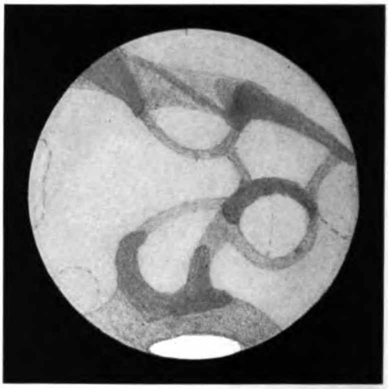


Fig. 14
Pickering
179° D

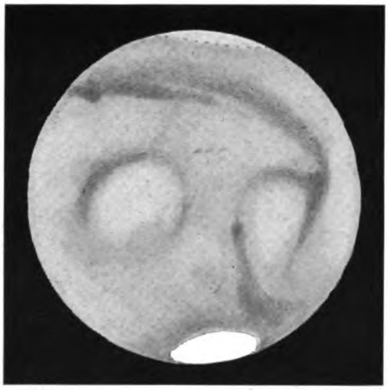


Fig. 17
Phillips
240° E

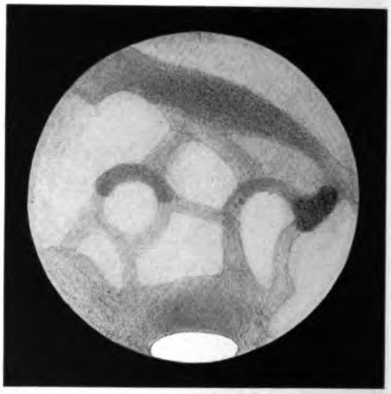


Fig. 18
Pickering
242° E

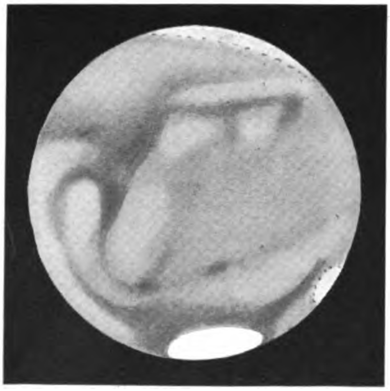


Fig. 21
Phillips
315° F

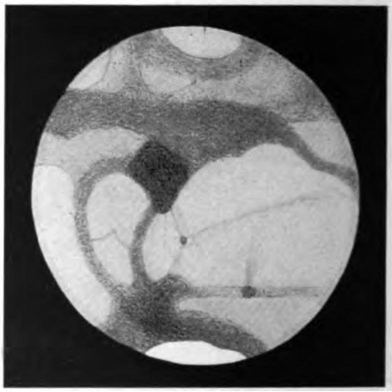


Fig. 22
Pickering
303° F

PLATE XLIII

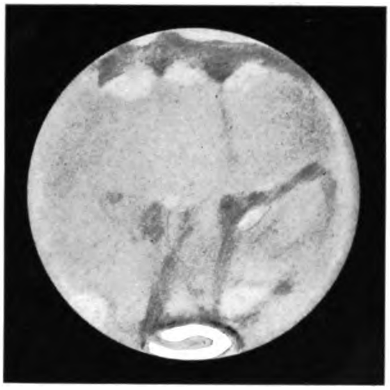


Fig. 15
Wilson
183° D

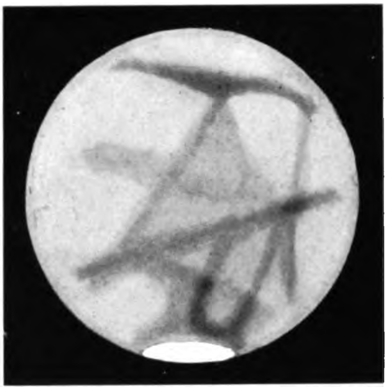


Fig. 16
Douglass
158° D

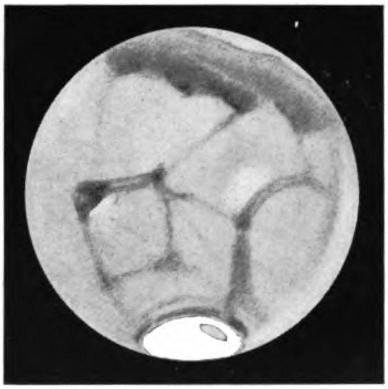


Fig. 19
Wilson
250° E

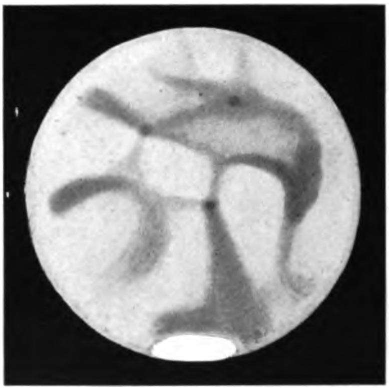


Fig. 20
Douglass
256° E

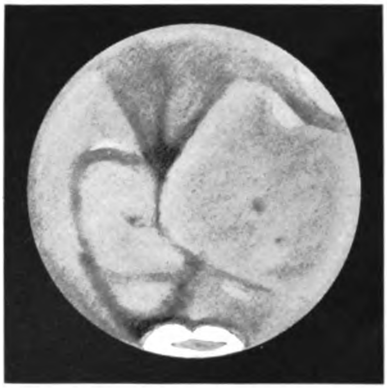


Fig. 23
Wilson
303° F

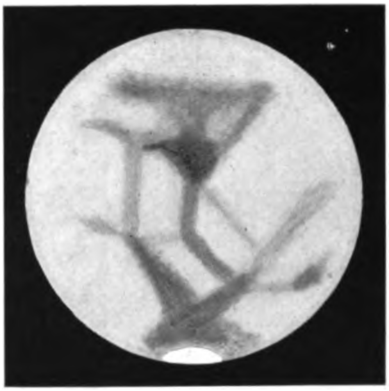


Fig. 24
Douglass
287° F

ures 25 and 26). If well defined, it should have been visible in their telescopes. Mr. Phillips shows it in Figure 1, drawn February 27. To the writer it was first suspected March 1, and clearly shown although only slightly marked March 5 (Figure 2). March 7 Professor Douglass writes regarding it, "Sabaeus Sinus possibly double, not sure." He does not show Aryn however in his sketch of that date (Figure 4). It may therefore be taken as fairly certain that it first became visible this year early in March. ⊙ 62° ± 2°, M. D. May 21. On the other hand it should be noted that Dr. Lowell shows it very conspicuously in his sketch of January 28, published in Popular Astronomy 1916, **24** Plates 26 and 27, 423, 426. He apparently did not notice that it was then invisible. The writer has an excellent drawing made January 30, seeing 9, which shows not a trace of it.

As an illustration of the differences that are sometimes found in the work of different observers, the canal Laestrigon is shown on Figures 15 and 19 by Mr. Wilson, and on Figures 16 by Professor Douglass as a straight line, yet on February 12 to the writer (Figure 14) it was clearly crooked. On March 21 and 24, however, he too drew it as straight. If it really was crooked, this shows about the maximum length of an average curved canal that present appliances will erroneously indicate as a straight line. Its length was 2″.8, or 800 miles, (1200 km).

This statement is corroborated by the fact that the larger telescopes, in Figures 14, 17, 18, and 20, represent Elysium as circular. In Figure 13 it is slightly angular and in Figures 15 and 19 clearly so, with four straight bounding canals. The circular form is confirmed by a drawing sent me some months ago, made at the observatory of M. Jarry-Desloges with a 12-inch objective. Dr. Lowell in his paper in Popular Astronomy, above mentioned, represents it still differently, with two straight sides and two curving ones, giving it a rather hexagonal form, but agreeing fairly well in general appearance with the majority. This is much too difficult a point to be decided by a small telescope, but it is of interest to note that in Figure 34 Mr. McEwen represents it as a square, strongly inclined to the position shown by Mr. Wilson in Figure 19, and that in Figure 32 one of the sides is slightly curved. In former oppositions it was often represented as a pentagon, with a strongly marked angle at the south. In 1916, however, it appeared circular to the writer.

No such rapid changes of detail are recorded on our drawings this year as were found in 1914. Indeed it is rather too late in the Martian season for such changes to present themselves, but there is nevertheless evidence of a flooding of the Syrtis marsh on two occasions. It will be recalled that one flood occurred about the end of December (Reports Nos. 14 and 15). The Syrtis then narrowed and dried up, as shown in

Figures 21 and 36, both taken on the same date, January 22. A very slight darkening is shown in both of them, but it is so slight that the observers do not agree very well as to its location.

Another flood occurred January 31, ⊙ 48°.3, as recorded on the Jamaica drawings, the flood broadening and spreading for the next few days, but by February 3 (Figure 23) Mr. Wilson shows that it had already begun to recede towards the northern tip of the Syrtis. The longitudinal canal Dosaron, however, still marked its central axis. The increased breadth of the Syrtis was now clearly noticeable. This recession of the marsh is confirmed by a Jamaica drawing of February 7. By February 23 (Figure 35) Dr. Lau shows that the Syrtis had again narrowed, and the dark area and canal had entirely disappeared. The canal is however faintly shown in a drawing by Mlle. Renaudot, made at Juvisy February 24, and more conspicuously in a drawing by M. Le Coultre of Geneva, dated March 1. It is is further shown in a drawing by M. Dufour on the same date (L'Astronomie 1916 **30**, 308, 269, and 270). The narrowing of the Syrtis and disappearance of the dark area is confirmed by all three of these drawings.

By March 9 (Figure 22) the Syrtis had broadened again, and the dark flooded area had become quite conspicuous. Four days later (Figure 24) according to Professor Douglass, the flood had receded slightly, and Dosaron had begun to appear, but the width of the Syrtis was still as great as ever. This is the last great flood in this region of which we have any evidence. ⊙ 65°, M. D. May 27. The approximately square flooded area measured at maximum about 700 miles (1100 km) on a side, thus indicating the power of our Sun even at the distance of Mars.

As pointed out two years ago, these floods on the Syrtis should be carefully observed in the springtime of the Martian year. Every interested observer should draw the Syrtis every night that it is visible to him at the next opposition, timing his drawing so that the Syrtis shall be as near as possible to the central meridian. See Report No. 15 for instructions how to compute the time. Then by combining the observations made in Europe with those made in America, we could get a series of drawings for this particular Martian longitude extending through fully a half presentation of the planet, or twenty days. The next opposition will be our last chance for several years. When a flood comes it begins to darken first towards the tip of the Syrtis, and gradually spreads and broadens, turning first dark and then blue. At length the southern boundary of the dark spot, which was at first indistinct, becomes sharply defined, and this gives us our first definite date for the flood. The blue color and the sharpening of this boundary are the most definite indications that we have, and observers should be particularly on the lookout for them in the future.

IDENTIFICATION OF THE CANALS.

The identification of the canals and lakes of this opposition has been made by means of our standard map published in connection with Report No. 15. This map, which is probably the best yet constructed, has proved very satisfactory, and much better than its predecessor, but careful study has shown certain defects in it which may be pointed out in this place. It would be better if it contained a few more canals, and also a few more lakes. As in the case of the previous opposition, it has been necessary occasionally to refer for an identification to Lowell's map of 1896 (Annals 3, 100) and sometimes to his other maps, and to that of M. Jarry-Desloges (Observations 3). Several of the canals shown are taken from Lowell's maps, but one of them, Evenus, leading northeasterly from Titanum Sinus is wrongly named. It should be called Steropes, Evenus according to Lowell indicating another canal in the immediate vicinity. Cyclops to the north of Elysium should be considerably more inclined, as it was drawn by Schiaparelli. Nuba Lacus, situated on Thoth, should, according to all observers who recorded it this year, be located appreciably farther to the south,—perhaps 10° for the average. There seems to be some ambiguity about a few of the canals to the north of Solis Lacus, lying between Aurorae Sinus and Phoenicis Lacus. The accompanying sketch map Figure I shows the names which it has been decided to adopt in these Reports. The three small lakes are Messeis, Tithonius and Phoenicis, the first named by Lowell in 1896 (Annals 3, 100).

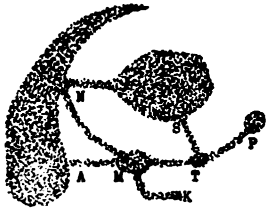


Fig. 1

The canal N M as is shown by the standard map is Agathodaemon, so named by Schiaparelli.

The canal M T P is Daemon, so called by Lowell in 1901 (Annals 3, 144).

The canal A M has been called Agathodaemon by Lowell in 1896, 7, (Annals 3, 100). It has been called Coprates by Desloges in 1912, (Observations 3, 317) but this name Lowell has already applied to another canal in this immediate vicinity. On our standard map the name Ophir has been placed immediately below it, but the type employed indicates a region, not a canal. The name Ophir is however a good one, and it is proposed to adopt it for this canal.

The canal ST is Tithonius, so named by Lowell (Annals 3, 100).

The little crooked canal MK is occasionally prolonged to T. It was first seen, it is believed, by the writer in 1892, when it was also drawn by Professor Douglass. It appeared again in 1914 (See Report No. 8), where it was sketched by Professor Douglass, Figure 7. It had again appeared this past year, see Figures 6 and 12. In the Lowell Annals 2 the name Agathodaemon has been applied to a portion of it, on a map which has been superseded in Volume 3, Append. 24. On the latter map this use has been discontinued. It is otherwise unnamed. It is now proposed to call it Kedron.

The identification of a large number of canals and lakes always involves the exercise of a certain amount of judgment, for not only do the observers themselves sometimes draw them in the wrong places, but also, in the case of the canals, sometimes in the wrong position angle. Moreover, as we have already seen, these objects sometimes shift their positions, travelling occasionally several hundred miles over the surface of the planet. If even the clearly marked ones, whose latitudes and longitudes we are able accurately to determine, do this, what shall we do with the fainter ones, which we can only just distinguish? Under the circumstances it is perhaps surprising that any two specialists will agree on the proper names for the markings as well they do, or that the same observer will corroborate his own identifications at different oppositions. Of course the conspicuous markings are easy enough; it is usually only the fainter ones that give trouble.

The best method to adopt, is first to determine the latitude and longitude of the central point of the disk, and then to name the more obvious markings. We next determine the latitude and longitude of any point near the centre by means of a central point. It is always well to identify the lakes first. For the canals their position angles will also help. Finally in many cases assistance may be derived from the neighbouring detail.

In Table II is given a list of all the canals shown on the drawings of the six observers. The canals are arranged and numbered alphabetically, and the successive columns indicate in which drawings of each observer the canal is found.

The dark areas bounded on one side by the polar cap, and which often coincide more or less closely in position with some of the canals given on the map, are not considered to be really canals, unless they are clearly separated from the snow. As shown in Report No. 14 they appear to be more ephemeral in their nature, often changing in breadth and visibility in the course of a few hours, and in any case clearly

PLATE XLIV

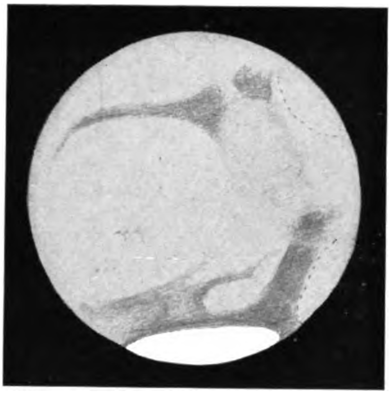


Fig. 25
Lau
350° A

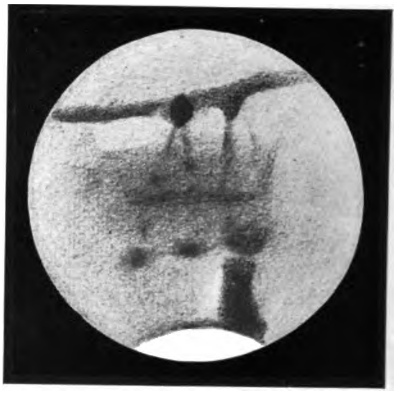


Fig. 26
McEwen
4° A

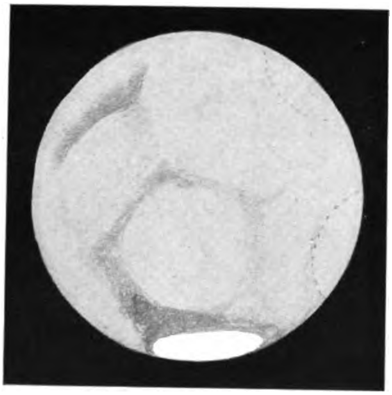


Fig. 27
Lau
62° B

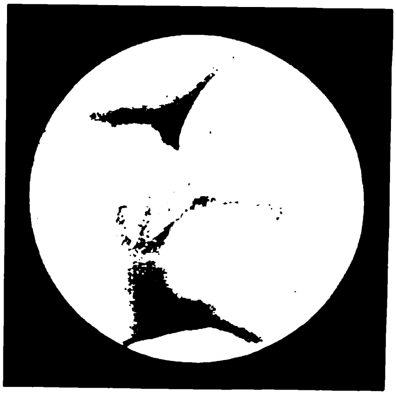


Fig. 28
McEwen
64° B

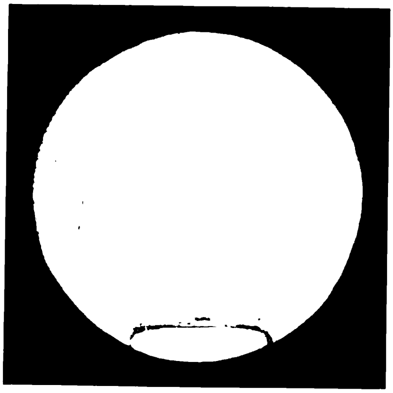


Fig. 29
Lau
128° C

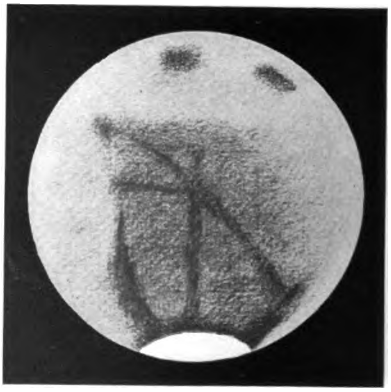


Fig. 30
McEwen
124° C

PLATE XLV

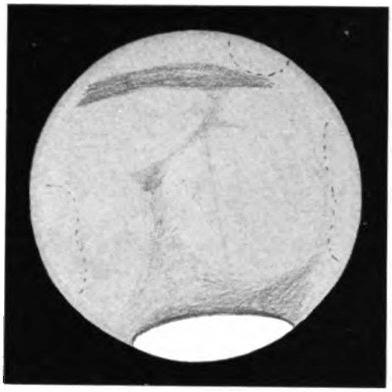


Fig. 31
Lau
213° D

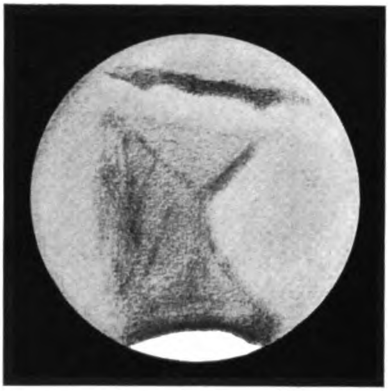


Fig. 32
McEwen
184° D

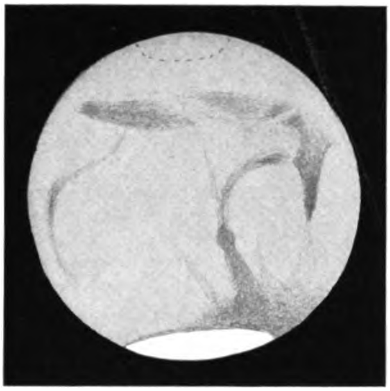


Fig. 33
Lau
244° E

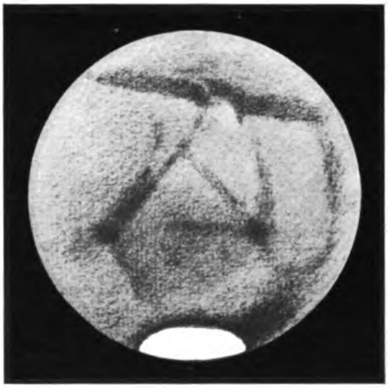


Fig. 34
McEwen
230° E

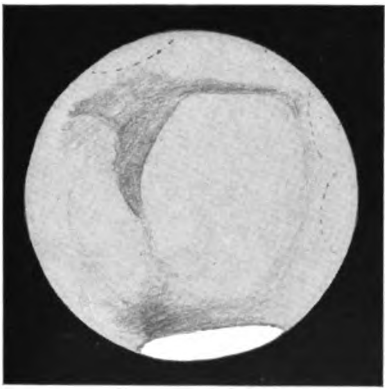


Fig. 35
Lau
304° F

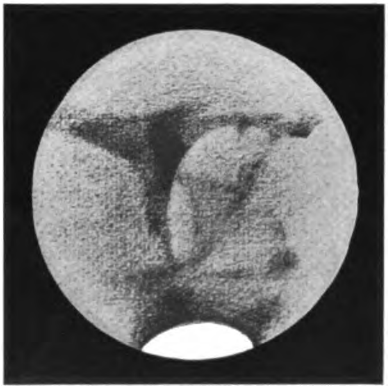


Fig. 36
McEwen
303° F

TABLE II.

Canals Identified on the Drawings.

No.	Canal	Pl	Pk	W	D	L	M	Obs.
1	Acheron		C *		D			2
2	Aesacus			E				1
3	Aethiops						E	1
4	Alander (L)					BC		1
5	Anian			DE				1
6	Asopus						F	1
7	Astusapes		F·	DE	F		F	4
8	Avernus		D				D	2
9	Boreas		E					1
10	Boreosyrtis	E	E	F	EF		F	5
11	Bosporus		B		C			2
12	Brontes	C	D	D	CD	C	C	6
13	Casius	EF	EF	FF	EF	EF	E	6
14	Ceraunius	C	C	C	C	B	BC	6
15	Cerberus	DE	DE	DE	DE	DE	DE	6
16	Chaos		DE	DE				2
17	Chlorus (L)				B			1
18	Cyane (L)				B			1
19	Cyclops	E	DE	E	E	DE	E	6
20	Daemon (L)	BC	BC		C			3
21	Dargamanes (L)				B			1
22	Deuteronilus	FA	FA	A	AB	A	A	6
23	Dosaron (L)			F	F			2
24	Erebus		D		D		D	3
25	Eumenides	D	C		D			3
26	Eunostos	DE	DE	DE	EF	D	E	6
27	Euphrates	F	F	A	A		F	5
28	Fortuna			C				1
29	Ganges		B	B	BC			4
30	Gehon		A	AB	AB		A	4
31	Gigas		C	C	C	C	C	5
32	Granicus			D				1
33	Hades	D	DE	D	D		D	5
34	Hebrus			C			C	2
35	Hephaestus		E	E	E			3
36	Hiddekel					F	A	2
37	Hyblaeus	E	DE	E	E	D		5
38	Hydaspes						AB	1
39	Indus		A	AB	AB	B	A	5
40	Jamuna			B				2
41	Jordanis				A		AB	2
42	Kedron (P)		B		C	A		2
43	Laestrigon		D	DE	D			3
44	Laus (L)				E			1
45	Lycus		C	C	C			4
46	Nar (L)			E			C	2
47	Nasamon		F		F		E	2
48	Nectar	BC	B	B	BC			4
49	Nepenthes	EF	EF	EF	E	E		5
50	Nilokeras	BC	A	B	B	AB		6
51	Nilosyrtis	EF	EF	EF	EF	EF	B	6
52	Nilus	C			C	B	F	3
53	Ophir (P)	BC	B	B	C			4
54	Orcus	D			D			3
55	Oxus		A	A	A		D	3
56	Pandora	F	F	A	A			5
57	Phison	F			F		F	2
58	Phryxus (L)			B				1
59	Protonilus	FA	FA	FA	FA	F	F	6

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* Editor's Note:—The letters in this table refer to the corresponding heavy face letters in the titles of Figures.

TABLE II.—CONTINUED.

No.	Canal	Pl	Pk	W	D	L	M	Obs.
60	Pyramus			F				1
61	Simois		D					1
62	Sirenius					B	C	2
63	Sitacus	F	F	A	A		F	5
64	Steropes (L)				D			1
65	Styx	D	DE	DE	D	DE	DE	6
66	Subus (D)		F	F	F			3
67	Tartarus		D		D			2
68	Thoth	EF	EF	EF	EF	EF	E	6
69	Titan						D	1
70	Triton		E	E	EF	E	E	5
71	Uranius	C			C		B	3
72	Anon. (*a*)				A	A		2
73	" (*b*)					E		1
74	" (*c*)					E		1
75	" (*d*)						A	1
76	" (*e*)						D	1
77	" (*f*)						D	1

differ from the canals properly so called. In accordance with this view they have been omitted from the table. Ten canals not given on our map have been identified on that of Dr. Lowell. Their names are all followed by an (L). One canal, Subus, followed by a (D) was identified on the map of M. Jarry-Desloges. Six other canals could not be identified, and are recorded as anonymous. They may be described briefly as follows:

Anon. (*a*) This canal lies just to the south of Deuteronilus. It connects with Margaritifer through Oxus which has shifted to the south to connect with it, and now leads directly to Ismenius instead of to Siloe.

Anon. (*b*) Preceding and nearly parallel to Casius.

Anon. (*c*) Following and nearly parallel to Casius.

Anon. (*d*) Parallel to Deuteronilus and 0.4 of the distance towards Sabaeus.

Anon. (*e*) Preceding Titan and slightly inclined to it.

Anon. (*f*) Following Titan and slightly inclined to it.

The last column of the table gives a number of observers by whom each canal was seen.

STATISTICS OF THE CANALS.

A statement of the number of canals recorded is given in Table III, where the first column indicates the visibility, by the number of observers who recorded the canals, and the following columns the number of such canals recorded by each observer, and the total. Thus, of those canals recorded by all six observers, Mr. Phillips saw 12, of those recorded by five observers, he saw 7, etc. The next to the lowest horizontal row shows the number of canals seen that were confirmed by at least one other observer, and the lowest row the total number seen. The three southern observers saw more canals than the three northern ones, which was perhaps to be expected, since the seeing seems to be a function of the latitude. Indeed they each saw all of the canals recorded by six, five, and four observers, 28 altogether. They saw 32 canals in all in common. It was only in the canals seen by but three observers where they began to break down. The last column shows that there were ten of these, all of which were seen by Professor Douglass. Dividing the observers into these two classes, it would seem that the special usefulness of the northern observers was to classify the more conspicuous canals as to their relative visibility, and to confirm the fainter canals when possible. The usefulness of the southern observers is to find the fainter canals, and determine their relative visibility when found. Both classes of observers are therefore needed in this investigation. It cannot be too strongly emphasized however that all the drawings are useful for studying the existence, location, and shapes of the more conspicuous markings, and that this work is considered of far more importance than the discovery of the fainter canals, Observers are again cautioned not to see too many faint and doubtful canals.

TABLE III.

THE NUMBER OF CANALS RECORDED.

Obs.	Pl	Pk	W	D	L	M	Total
6	12	12	12	12	12	12	12
5	7	10	10	10	5	8	10
4	2	6	6	6	1	3	6
3	5	7	4	10	1	3	10
2	1	7	5	9	4	6	16
1	0	2	6	4	4	7	23
Confirmed	27	42	37	47	23	32	54
Total	27	44	43	51	27	39	77

Owing to the fact that Mr. Wilson's observatory is so near the track of the great anti-cyclone disturbances, which are undoubtedly the prime source of all the bad seeing that we experience, he might properly be classified with the northern observers, whom he would then lead as far as the number of canals recorded are concerned. He really holds a position intermediate between the two classes, but owing to the lack of southern observers we have classified him with them.

On the principle of the division of labor among the observers, it has been decided, even at the risk of losing several of the canals that were really there, to omit all those recorded by the northern observers which were not confirmed by at least one of the southern ones. This measure has not been applied to the canals recorded at the southern observatories, because it seemed more likely that a favorably situated observer, such for instance as Professor Douglass, who saw a great many canals that were confirmed by others, might very well have seen a few which no one else had recognized. This plan will eliminate the following canals from our list:—Aethiops, Alander (L) Asopus, Cyane (L), Hiddekel, Hydaspes, Sirenius, Titan, and five of the six anonymous canals. This reduces the total number of canals from 77 to 64. It should be pointed out that this does not indicate the total number of canals seen by all of the observers at this opposition, but only the total number seen on certain selected drawings. Earlier and later, moreover, other canals appeared not here recorded.

On our finally accepted list the following canals have been seen by all six of the observers: Brontes, Ceraunius, Cerberus, Cyclops, Casius, Deuteronilus, Eunostos, Nilokeras, Nilosyrtis, Protonilus, Styx, and Thoth.

Five observers saw Boreosyrtis, Euphrates, Gigas, Hyblaeus, Hades, Indus, Nepenthes, Pandora, Sitacus, and Triton.

Four observers saw Astusapes, Gehon, Ganges, Lycus, Nectar, and Ophir.

Three observers saw Daemon, Erebus, Eumenides, Hephaestus, Laestrigon, Nilus, Orcus, Oxus, Subus, and Uranius.

Two observers saw Acheron, Avernus, Bosporus, Chaos, Dosaron, Hebrus, Jamuna, Jordanis, Kedron, Nar, Nasamon, Phison, Tartarus, and Anonymous (*a*).

One observer only saw Aesacus, Anian, Boreas, Chlorus, Dargamanes, Fortuna, Granicus, Laus, Phryxus, Pyramus, Simois, and Steropes.

The arrangement of Table IV is similar to that of Table III, except that instead of giving the total number of canals seen by each observer, it gives the proportion of the total number recorded. These total numbers are given in the last column, as modified by the above mentioned omissions. As we descend the columns to fainter and fainter canals, the proportion of the total number seen by each observer should rapidly decrease, and this we find in general to be the case. We note by the last column that as the canals grow fainter, they first decrease, and then increase in numbers, averaging eleven to each class. The lower row of the table gives the modified number of canals seen by each observer.

TABLE IV.

PROPORTION OF THE CANALS VISIBLE TO THE DIFFERENT OBSERVERS.

Obs.	Pl	Pk	W	D	L	M	Total
6	1.00	1.00	1.00	1.00	1.00	1.00	12
5	.70	1.00	1.00	1.00	.50	.80	10
4	.33	1.00	1.00	1.00	.17	.50	6
3	.50	.70	.40	1.00	.10	.30	10
2	.07	.50	.36	.64	.14	.29	14
1	.00	.17	.50	.33	.00	.00	12
Total	27	44	43	51	21	30	64

In the opposition of 1914 nearly all the canals were broad, while the more difficult ones were faint. To detect them therefore did not require particularly good seeing, but it did require an eye sensitive to small contrasts. In 1916 more narrow canals appeared, especially immediately after the opposition, good seeing was therefore more important. It is expected that still more of the narrow canals will appear in 1918. These will require large apertures, that is to say as large as the climate of the observer will permit. Apertures as large as 12 inches can probably be used to advantage at times in northern Europe, and still larger ones in the Mediterranean section. Observers should not forget, however, that when the seeing is poor, a very appreciable advantage may be gained, on bright objects like the Moon and Mars, by reducing their apertures.

COMPARISON OF THE OPPOSITIONS OF 1914 AND 1916.

Comparing the past year's work with that of the previous opposition (Report No. 8), we notice first that the present drawings were made appreciably later in the Martian calendar year. The earlier observations were all taken between ⊙ 5°.5 and 26°.1, corresponding on the Revised Calendar of Report No. 10 to between the Martian dates of March 12 and 54. By Table I, the present set of drawings were made between ⊙ 44°.2 and 66°.7 corresponding to the Martian dates of April 37 and May 31. As a result on comparing the two sets of drawings, we notice at once that the northern snow cap has appreciably decreased in size. It has turned also more directly towards us. In 1914 the central latitude lay between +2° and +9°. This year it lay between +14° and +18°. The maximum size of the planet was somewhat less, 13″.9 against 15″.0,—indeed such a remote opposition is unusual, and will not occur again for many years.

There was a general complaint of poor seeing among the different observers. Professor Douglass found little difference, however; his range of seeing on the standard scale in 1914 was 5 to 9, and in 1916, 6 to 9.

For the writer in 1914 it was 10 to 12, averaging 10.5, and this year 5 to 12, with a rather low average of 8.4. Yet in spite of the smaller disk and poorer seeing, he saw more canals, and they were increasing in number when the time limit for the drawings expired. Moreover this year there were no canals visible in the Protei regio, region B, where owing to a flood a number were seen before.

Treating the matter statistically with regard to the more conspicuous and therefore assured canals, we find that in 1914 there were 24 that were seen by all three observers. Three of these lay at the border of the polar cap, and adopting this year's regulation, they were eliminated as not being really canals, properly speaking. Achelous (L) also, in fact appeared on only two of the drawings in 1914, Mr. Phillips' representation coinciding more nearly with Cyclops than Achelous. Phlegethon was very faint on two of the drawings, so much so indeed that it shows only in the reproduction of the drawing by Professor Douglass, Figure 15. These canals will also be eliminated, leaving 19, which we will compare with the 22 seen this year, by six and by five observers.

TABLE V.

COMPARISON OF THE CHIEF CANALS SEEN IN 1914 AND 1916,

Part I				Part II			
1914	Vis.	1916	Vis.	1916	Vis.	1914	Vis.
Agathodaemon	6	Ophir	4	Brontes	6	Titan	4
Boreas	6	Boreas	1	Cyclops	6	Cyclops	2
Boreosyrtis	6	Boreosyrtis	5	Euphrates	5	Euphrates	4
Bereosyrtis	6	Casius	6	Hades	5	Hades	4
Cerberus	6	Cerberus	6	Indus	5	Indus	4
Daemon (L)	6	Daemon (L)	3	Protonilus	6	Protonilus	4
Deucalionis	6	Pandora	5	Sitacus	5	Hiddekel	4
Deuteronilus	6	Deuteronilus	6	Triton	5	Triton	4
Eunostos	6	Eunostos	6				
Gigas	6	Gigas	5				
Hyblaeus	6	Hyblaeus	5				
Lapaden (L)	6	Ceraunius	6				
Nectar	6	Nectar	4				
Nepenthes	6	Nepenthes	5				
Nilokeras	6	Nilokeras	6				
Nilosyrtis	6	Nilosyrtis	6				
Styx	6	Styx	6				
Tartarus	6	Tartarus	2				
Thoth	6	Thoth	6				
Tithonius	6	——	0				

In the first part of Table V the first column gives these nineteen canals. The second column gives their visibility, calling those seen by all three observers 6. Those that were seen by two observers are marked in another column 4, and those seen but by one observer 2. The third column gives the corresponding canals seen in 1916, and the fourth their visibility taken from the last column of Table II. Since different maps were used in the identification in the two oppositions, this sometimes causes a change in the name of the canal, but allowing for this fact, in most cases the difference in recorded visibility is not very great. Certain exceptions occur, however, Boreas being seen by but one observer this year, Daemon by but three, Tartarus by two, and Tithonius not at all.

In the second part of the table the first two columns refer to the past opposition, and contain the names of the remainder of the clearly visible canals, the other columns referring to the opposition of 1914. The only marked change recorded is that of Cyclops, which, as above stated, was seen by one observer in 1914. Achelous and Cyclops are parallel and lie side by side, although 700 miles apart, both connecting Cimmerium with Elysium. Since the former was clearly visible in 1914, and the latter alone the past opposition, we may well wonder if the latter really took the place of the former in the physical economy of the planet, and if so in what way.

THE LAKES OF MARS.

A list of the 33 lakes seen by the different observers is given in Table VI which is arranged exactly like Table II. There are two or three curious points about it. No single lake was seen by all six observers. Ismenius and Lunae were the two most frequently recorded. Oddly enough Solis was not seen at all with the two smaller instruments, presumably because it was so near the southern limb. The two observers who saw the most canals were with one exception the two who saw the fewest lakes. The anonymous lakes were located as follows:—*A* 100°, +30°,

TABLE VI.

LAKES IDENTIFIED ON THE DRAWINGS.

No.	Lake	Pl	Pk	W	D	L	M	Obs.	No.	Lake	Pl	Pk	W	D	L	M	Obs.
1	Acidalius (L)				AB			1	18	Nuba	E		EF	E	E		4
2	Ammonium			D				1	19	Orontes (D)			A			A	2
3	Arethusa			A				1	20	Oxia		A					1
4	Ascraeus						C	1	21	Pambotis			DE				1
5	Caloe	F	F	F				3	22	Phoenicis						C	1
6	Castorius				D			1	23	Propontis I	D						1
7	Charontis			DE	D	D	D	4	24	Propontis II	D						1
8	Coloe (L)			F				1	25	Pseboas		F					1
9	Cyclopum (L)				E			1	26	Siloe			A			A	2
10	Hecates	D		E				2	27	Solis	BC	BC	B	C			4
11	Hesperidum (L)				E			1	28	Stymphaline	D						1
12	Ismenius	AF	AF	A	AF		AF	5	29	Triviae (L)			D			E	2
13	Lunae	B	B	B		B	B	5	30	Anon *A*	B						1
14	Maricae			D				1	31	" *B*	D						1
15	Messeis (L)	C	B	C				3	32	" *C*						E	1
16	Morpheos (D)			DE				1	33	" *D*			F				1
17	Niliacus	AB		B		A	A	4									

B 180°, +60°, *C* 235° +20°, and *D* 275°, +25°. Only twelve lakes out of the 33 recorded were seen by more than one observer, which leads one to wonder if all the others were real. These twelve named in the order of their visibility were (5) Ismenius, Lunae, (4) Charontis, Niliacus, Nuba, Solis, (3) Messeis (L), Caloe, (2) Hecates, Morpheos (D), Siloe and Triviae. Of these Wilson saw all 12, Phillips 8, McEwen 7, Pickering 5, and Douglass and Lau 4 each. Only 6 of them were seen at the previous opposition, namely Messeis, Niliacus, Charontis, Solis, Caloe, and Nuba. The last two were those designated as anonymous, numbers 21 and 22, since they were not given either on Schiaparelli's or Lowell's map.

Table VII contains the usual data for the final drawings of the opposition, that were made in Jamaica. These were omitted from the last report on account of its length.

TABLE VII.

DATA OF THE DRAWINGS.

No.	1916	⊙	M. D.	Long.	Lat.	Sun	Diam.	Seeing
68	Feb. 28	60°.0	May 18	30°	+15°	+21°	13″.0	10
69	Mar. 1	61.5	" 19	3	14	"	12.9	8, 7
70	" 1	"	" "	35	"	"	"	7, 6
71	" 5	63.2	" 23	0	"	"	12.5	9, 7
72	" 8	64.5	" 26	332	"	22	12.3	9
73	" 9	65.0	" 27	303	"	"	12.2	10, 12
74	" 11	65.8	" 29	273	"	"	12.0	9, 7
75	" 19	69.3	" 37	246	"	"	11.3	6, 4
76	" 21	70.2	" 39	209	"	"	11.0	9, 10
77	" 24	71.5	" 42	180	15	"	10.8	10, 9
78	" 26	72.4	" 44	149	"	23	10.6	7, 8
79	" 29	73.7	" 47	121	"	"	10.3	9, 10
80	" 31	74.5	" 48	96	"	"	10.1	9, 6
81	Apr. 5	76.7	" 54	46	"	"	9.7	8, 10
82	" 5	"	" "	62	"	"	"	11, 12
83	" 6	77.1	" 55	33	16	"	9.6	9, 7
84	" 7	77.6	" 56	9	"	"	9.5	11, 10
85	" 12	79.8	June 5	331	"	24	9.1	6
86	" 17	82.0	" 9	297	17	"	8.6	8, 9
87	" "	"	" "	331	"	"	"	8, 9
88	May 1	88.2	" 23	183	18	"	7.9	6
89	" 3	89.0	" 25	122	"	"	7.8	7, 6
90	" "	"	" "	158	"	"	"	8

The following canals and lakes were seen:

Feb. 28	**A**	Protonilus. Deuteronilus.
Mar. 1	**AB**	Protonilus, Deuteronilus, Jordanis, Gehon, Oxus, Indus, Jamuna, Nilokeras, Ganges, Chrysorrhoas, Ophir, Anonymus, and Ismenius, Siloe, Oxia.
Mar. 5	**A**	Protonilus, Deuteronilus, Gehon, Oxus, Indus, Nilokeras, and Ismenius, Oxia.

Mar. 8	**A**	Nilosyrtis, Protonilus, Deuteronilus, Gehon, Jordanis.
Mar. 9	**F**	Thoth, Nepenthes, Casius, Nasamon, Subus, Nilosyrtis, Asteropes, Sitacus, Euphrates, and Ismenius, Caloe, Coloe.
Mar. 11	**F**	Cerberus, Cyclops, Eunostos, Hyblaeus, Anian, Hephaestus, Nepenthes, Thoth, Casius, Nasamon, Subus, Nilosyrtis, Astusapes, Protonilus, Anonymous.
Mar. 19	**E**	Cerberus, Styx, Cyclops, Eunostos, Hyblaeus, Nepenthes, Thoth, Casius, Nilosyrtis.
Mar. 21	**D**	Erebus, Hades, Styx, Cerberus, Cyclops, Eunostos, Hephaestus, Hyblaeus, Chaos.
Mar. 24	**D**	Lycus, Brontes, Erebus, Tartarus, Hades, Styx, Cerberus, Cyclops, Eunostos, Hyblaeus.
Mar. 26	**C**	Gigas.
Mar. 29	**C**	Daemon, Ceraunius, Gigas, and Solis.
Mar. 31	**C**	Jamuna, Nilokeras, Ganges, Chrysorrhoas, Nilus, Ophir, Daemon, Kedron, Ceraunius, Gigas, Iris, and Solis.
Apr. 5	**BB**	Oxus, Indus, Iaxartes, Tanais, Jamuna, Nilokeras, Ganges, Chrysorrhoas, Uranius.
Apr. 6	**B**	Gehon, Deuteronilus, Oxus, Indus, Callirrhoe, Iaxartes, Tanais, Nilokeras, Ganges.
Apr. 7	**A**	Protonilus, Deuteronilus, Jordanis, Gehon, and Ismenius.
Apr. 12	**A**	Nilosyrtis.
Apr. 17	**FA**	Thoth, Casius, Nepenthes, Nilosyrtis, Astusapes, Protonilus, Deuteronilus, and Caloe, Ismenius.
May 1	**D**	Cerberus, Styx.
May 3	**CD**	Daemon, and Phoenicis.

Mandeville, Jamaica, B. W. I.
Nov. 3, 1916.

NINETEENTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

[*Continued from page 589.*]

SPECTROGRAPHIC OBSERVATIONS OF RELATIVE MOTIONS WITHIN THE PLANETARY NEBULAE.

By W. W. Campbell and J. H. Moore.

In the past nine months, as opportunity offered, the D. O. Mills three-prism spectrograph on the 36-inch Lick telescope has been used in search for rotation effects in thirty-three planetary nebulae. Definite evidence of rotation has been observed in sixteen nebulae and suspected in five others. In twelve nebulae no evidence of rotation was obtained, possibly because the axis of rotation in some of these may be pointing approximately toward the Earth; in which case the spectroscopic method would not be applicable.

In the nebulae which are more and more condensed as the center is approached, we seem to be dealing with simple cases of rotating bodies, with the outer strata rotating more slowly than the strata nearer the center. In other nebulae, which are of a ring form with central nuclei, rotation effects seem to be combined with other forms of motion.

The results give valuable evidence as to the probable masses of the planetary nebulae. They seem to contain sufficient material to form systems more extensive than our solar system.

The paper was illustrated with lantern slides of a few of the nebulae and their spectra.

THE SPECTRAL TYPE AND RADIAL VELOCITY OF BARNARD'S PROPER MOTION STAR.

By W. W. Campbell and J. H. Moore.

Two spectrograms, obtained with the 36-inch refractor and a single prism spectrograph with six-inch camera, show that the spectral type of this star is Mb, that its radial velocity is about −128 kilometers per second, and that it is a "dwarf" star, according to Adams' spectral test, comparatively close to us.

PECULIAR SPECTRA FOUND IN PREPARING THE NEW DRAPER CATALOGUE.

By Annie J. Cannon.

The spectroscopic survey of the entire sky for the formation of the New Draper Catalogue has resulted in the classification of 241,179 spectra, representing about 218,000 stars. The limiting magnitude for stars photographed at Cambridge is 8.5, for those taken at Arequipa, 9.0. Much time has been given of late to the re-examination and critical study of peculiar objects. It appears that less than one-fifth of one percent of these 241,000 spectra fall outside of the adopted classes known as B, A, F, G, K, M. But there are many peculiar spectra even among those which in general characteristics may be classed in one of these divisions.

Stars of the helium type having bright hydrogen lines form an interesting division of Class B. Twenty new ones have been found in this survey, besides numerous others in which $H\beta$ is so extremely faint and ill-defined that $H\alpha$ will probably prove to be bright.

Variable stars whose spectra are of class M generally have bright hydrogen lines at maximum. Three hundred and seventy-one of this class, called Md, were known before this survey, of which eighty-five were found, besides eleven new ones.

One hundred and thirty-four spectra which contain lines of two distinct classes have been observed whereas only thirty-three were known before. About one quarter of these are known to be double, either visually or spectroscopically. The others would form objects of interest for observations of velocity by means of a slit spectrograph.

In all classes of stellar spectra some stars have been found which show well marked lines of peculiar intensity. Thus in 1900, in *H. A.* **28**, 143, attention was called to a group of stars having the silicon lines at λ 4128 and λ 4131 stronger than normal, and to peculiar stars in various divisions from A2 to G0, having the strontium line λ 4077 very well marked. In 1908, *H. A.* **56**, 113, 114, 161, lists of these peculiar spectra were given. These lists have now been increased by several hundred. The group showing λ 4077 to be unusually strong is of interest since this was the first line whose intensity was proved to be connected with the absolute magnitudes of the stars. A line at about λ 3869 which may be the reversal of the well-known nebular line, has been found to be very strong in the star CPD −59° 3038, mag. 7.2.

By reason of discordant estimates real changes in the spectra of several stars have been found. Thus in 1895 the hydrogen lines in the spectrum of *Eta Carinae* were stronger and other bright lines were fainter than on later photographs. The spectrum of *R Scuti* changes from G5 at maximum to Mb at minimum.

Changes in the spectra of variable stars of short period were found by the writer nine years ago. In Circular 129, published May 10, 1907, it is stated that the spectrum of *TT Aquilae*, a variable of the *Eta Aquilae* class, changed from G at maximum to K at minimum. Observations for the New Draper Catalogue confirmed this change, the range observed being from G5 to K2. Also in *UX Centauri* a change from F2 to G5 was found. Photographs showing these changes were exhibited, also enlargements of photographs of *Delta Cephei* taken October 11 and October 12, 1907, in which, as stated in *H. A.* **56**, 110, the hydrogen lines were stronger on October 12. On the latter date the star was near maximum.

The only new type of spectrum which has been found is that of a very red star BD + 43°53. Its spectrum consists entirely of light near the region of Hα. Photographs were shown of the spectrum of this star compared with those of Class A and Class K, and of its difference in brightness when photographed with blue and yellow light. Its color index is at least 5.4 magnitudes. This star and *S Cephei*, which has a similar spectrum, are the two reddest stars known at the present time.

THE SPECTROSCOPIC BINARY γ LYRAE.

By Clifford C. Crump.

The variable velocity of γ *Lyrae* was detected in 1909 by S. A. Mitchell from studies of the Yerkes Observatory spectrograms. He found that the lines appeared "suspiciously double" on some plates and concluded that the period was about 25.6 days. Measures of the plates by C. P. Olivier and others gave discordant results perhaps due to the overlapping of lines.

Professor Guthnick at the suggestion of Professor Frost has had the star under observation with his photo-electric photometer as one of a number of stars of early type, which show difficult or peculiar variation of spectra. Coöperating with Professor Guthnick, Professor Frost placed the star on the program for continuous observation during certain nights of the summer of 1916.

Study of these plates shows many lines double in certain instances and indicates a short period, probably of only a few hours. Data communicated by Professor Guthnick indicate a period of light variation between three and four hours. He states however that a constant period has not been found which will combine series of observations taken a few months apart.

Observations of the star are being continued.

FORMS OF PLANETARY NEBULAE.

By Heber D. Curtis.

The forms of fifty planetary nebulae have been studied on photographs made with the Crossley Reflector, using various lengths of exposure times in order to get the structural detail of the very bright central portions as well as the fainter outlying parts. The majority of the planetary nebulae show a more or less regular ring or shell structure, generally with a central star. Lantern slides were exhibited showing the various types observed.

ON THE WIDTHS OF HYDROGEN EMISSION LINES IN CLASS B SPECTRA.

By R. H. Curtiss.

The outer edge of the emission components of the hydrogen lines in certain class B spectra, flanked as they are by absorption, present fairly sharp features for measurement with single-prism dispersion. Thus determinations of the widths of such emission lines become possible.

These measured widths, when corrected for slit-width and diffraction by subtracting the measured widths of neighboring essentially monochromatic comparison lines, probably represent well the actual widths of these lines.

Data of this kind for ten stars, observing in the photographic region of the spectra indicate: (1) that there is a simple linear relation $\Delta\lambda = a\ (\lambda - \lambda_0)$, between wave-lengths and line widths for the hydrogen emission lines for any spectrum of this class; (2) that the slope of the line representing this relation increases as the width of the Hβ line increases; (3) that for an Hβ line width of approximately 3.25Å, the $\Delta\lambda$'s do not change with wave-length but for smaller values of the width of the Hβ line they decrease with increasing wave-length and for larger values they increase.

The explanation is suggested that the widths of these lines are due to two principal causes, vapor density or pressure and Doppler effects attributable to atmospheric currents and rotation. The Doppler effect which probably never produces great widening is a strong factor in the cases of narrow lines and tends to produce increased widening with decreasing wave-length with an approximately linear relation for short regions of the spectrum. In the wide lines vapor density and pressure are the predominating widening agencies and are more effective with increasing wave-length.

SOME STRUCTURE VARIATIONS IN HYDROGEN EMISSION LINES IN SPECTRA OF CLASS B.

By R. H. Curtiss.

One hundred and twenty Class B to Class F spectra have been observed to show emission lines of hydrogen bright enough to be recognized. All but four of these are included in the spectral classes B0 to A0. In general the lines of hydrogen in which emission is visible in these spectra have a characteristic structure consisting frequently of a relatively narrow central dark line with emission on either side of it. This emission is flanked on either side by wide diffuse absorption borders. In many cases, especially when the emission line is narrow, the central absorption is not visible, but the absorption borders are quite characteristic. The best interpretation of these features appears to be that a very wide absorption band produced in the lowest layers of the star's atmosphere is reversed by the emission of an extensive chromospheric layer and doubly reversed by the absorption of the outer atmospheric layer.

There are ten of these spectra in which line variations appear to be established. So far as our present knowledge goes these variations are probably of two classes: periodic, probably connected with close stellar systems, typified by β *Lyrae* and φ *Persei*, and progressive as typified by the fading of bright D3 in γ *Cassiopeiae* and the disappearance of bright Hγ, Hβ, and Hα in Pleione.

The emission lines of hydrogen in HR 985 and b^2 *Cygni* have been observed at Ann Arbor to change in a manner not yet fully understood. The variation consists in a change in the relative intensity of the two parts into which the emission line is divided by the central absorption. On spectrograms of HR 985 covering 49 days in 1912 the part of greater wave-length was distinctly stronger, while during 75 days in 1916 these relative intensities were strongly reversed. In the meantime between 1912 and 1916 the spectrum lines, both emission and absorption with the exception of the K line, were displaced about 45 km in the direction of greater wave-lengths. The facts suggest a long period variation associated with binary motion but the cause of such variation is very obscure. Similar line variations have been found in b^2 *Cygni* between 1911-12 and 1916.

A line variation of the progressive type is probably found in the case of f^1 *Cygni*. In 1904 the lines Hζ to Hβ were observed to be bright at Harvard. In 1911, as observed at Ann Arbor, Hζ, Hε, and Hδ were strong absorption lines. Hγ possessed an emission component of the same brightness as the neighboring continuous spectrum, that of Hβ was slightly brighter. In plates of 1912, 1915, and 1916, little or no trace of the emission remained in any hydrogen line in the photographic region while the central absorption had increased at least twofold in intensity. In the meantime there was a change of over 30 km in the position of the central absorption, due probably to unsymmetrical broadening. This variation of the emission lines in f^1 *Cygni* seems to indicate that an extensive atmosphere is not a sufficient cause for the production of emisson lines of hydrogen in Class B spectra.

THE EFFECT OF HAZE SPECTRUM ON SPECTROSCOPIC DETERMINATIONS OF THE SOLAR ROTATION.

By Ralph E. De Lury.

That the overlapping sky spectrum might be strong enough to lessen the rotational displacements of the spectrum lines from the limb of the Sun, was pointed out by Halm (Edinburgh, 1901-6), who consequently made observations on the clearest days. Observers of the solar rotation since then have tried to heed the warning. Measurements made by the writer in 1911 showed that when the sky is very clear there is very little lessening of the rotational displacements by the overlapping sky spectrum. Measurements in 1912 of limb and centre spectra blended in varying proportions showed a progressive lessening of the rotational displacements with decrease in intensity of the spectrum lines, due, of course, to the progressive increase of the ratio, (intensity of line, centre) : (intensity of line, limb), with decrease in intensity of the spectrum lines. Haze spectrum, which derives its character chiefly from the central part of the solar disc, will produce a similar *differential* effect when blended with limb spectrum, the amount of lessening of the rotational displacement depending on the relative intensities of the line in haze and limb spectra. The following results of measurements of the equatorial velocity of the solar rotation exhibit such an effect, which is consequently explainable as due to the presence of haze between the observer and the Sun, probably mostly in the terrestrial atmosphere as indicated by the Ottawa observations made on days of varying intensity of haze:

Mount Wilson, 1906-8. (Adams and Lasby).

	km/sec.
Reversing layer, mean of a number of weak lines, λ 4250,	2.06
λ 4227,	2.12
Hα at limb,	2.12
Hα 3 mm inside limb,	2.11

These results were explained by Adams as due to increase in velocity with increase in level in the solar atmosphere.

Mount Wilson, 1915, λ 5200. (St. John, Adams, and Ware).

					Mean
Intensity of lines	1	2	4.9	22	6.4
No. of lines	2	5	9	3	19
Velocity, km/sec.	1.924	1.933	1.945	2.043	1.950

These results were given in support of Adams' level hypothesis.

Ottawa, 1915-6, λ 5200. (De Lury).

					Mean	
Intensity of lines	1	2	5.3	22	5.3	
No. of lines	3	11	7	3	24	
March 11, 1916, very slightly hazy.	1.956	1.972	1.972	1.968	1.967	km/sec.
June 16, 1915, slightly hazy.	1.808	1.842	1.845	1.883	1.843	km/sec.
March 3, 1916, very hazy, haze varying.	1.738	1.760	1.814	1.887	1.816	km/sec.

These results show that as the haze increases in intensity, the value of the velocity of the solar rotation for a given line or group of lines decreases, and the difference between the values for weak and strong lines increases.

After due allowance is made for the personal and instrumental errors which are liable to be present, there will still be considerable variation in the measurements of the solar rotation by different observers depending on the degree of intensity of the scattered light from haze or optical surfaces, on the region of the spectrum and on the selection of lines. Strong lines in the red part of the spectrum should yield values most free from the effect of scattered light. (Duner and Halm obtained exceptionally large values for observations at λ 6300).

If results of observations made during various degrees of haziness be plotted with *Velocities* as ordinates and degrees of *Haziness*, (or what may be considered a function of haziness and therefore a rough measure of it, namely, *Difference in Velocity* between weak and strong lines) as abscissae, the asymptote to the resulting curve will cut the velocity axis at the value freed from the effect of scattered light. Such a curve may be plotted for each line or for the mean. A large series of observations, in which a sufficient range of degrees of haziness is represented, thus contains the means of eliminating the effect of haze for any line or group of lines, if it be assumed that the solar rotation is constant during the period of the observations. Some series of observations, in which the effect of haze is supposed to be small, indicate a negative difference between the values of velocity for weak and strong lines, thus pointing to the possibility of a decrease in angular velocity with increase in level in the solar atmosphere, a conclusion which is the reverse of that of Adams. In general, values of the solar rotation observed during the last three years are smaller than those obtained during 1910-13; this is probably due to the fact that in general the terrestrial atmosphere has been getting hazier as a result of increased ionization accompanying increased spottedness of the Sun. All constants of the formulae derived for the solar rotation are of course affected by the presence of the spectrum of scattered light. It seems quite probable that the velocity of the solar rotation will be found invariable when the effect of scattered light is eliminated. It is scarcely necessary to add that the spectrum of scattered light affects differentially all measurements of wave-length and character of solar spectrum lines, and that the measurements of the differences between centre and limb spectra and of the displacements in the penumbra of spots are liable to be profoundly affected.

NOTE ON A SUPPOSED VARIATION IN THE SOLAR ROTATION.

By Ralph E. De Lury.

In the *Astrophysical Journal*, March 1916, is published a paper by H. H. Plaskett, entitled, "A Variation in the Solar Rotation", in which the conclusion is reached "that the Sun, during the summer of 1915, underwent a cyclic variation in its rotation rate with a range of 0.15 km. This variation was completed in about a month." Sample results from observations made during the period in question on days of different degrees of haziness and from lines of different intensity are given in the following table.

	July 13, hazy	July 20, bright
H. H. Plaskett's values for five lines of intensities 3 to 8, λ 5900,	1.846 km/sec.	2.026 km/sec.
De Lury's values		
4225.6, Fe, 3	1.712	1.966
4226.9, Ca, 20	1.794	1.983
4232.8, Fe, 2	1.711	1.972
Difference between Ca lines and Fe lines	0.082	0.014

Thus the variation in question is due to the variation in terrestrial haze.

AN EXTENSION OF BURNHAM'S GENERAL CATALOGUE OF DOUBLE STARS.

By Eric Doolittle.

Ten years ago, some 13,665 double stars had been discovered. At this time a great "General Catalogue" in two volumes was published by Mr. S. W. Burnham, who is the highest living authority on this branch of astronomy. This catalogue contained a description of the position of each one of these objects in the sky, with reference to all measures ever made upon it, and a critical discussion of each case, telling which pairs were known to be actually two suns revolving about one another, which were merely drifting past one another, and on which ones the evidence was not yet sufficient to enable us to determine what the true nature of the system is. The work was a very complete, an almost an exhaustive one. The present paper tells of the labor, undertaken at the Flower Observatory some six years ago, of bringing this catalogue up to date. Since it appeared, some 8,000 new pairs have been discovered and a great number of new observations have accumulated from the continuous measures made at many of the leading observatories of the world. The inclusion of this material and its discussion is perhaps two-thirds completed, but the entire completion of the extension of the General Catalogue will probably require about two years more.

FIRST RESULTS ON THE DEARBORN OBSERVATORY PARALLAX PROGRAM.

By Philip Fox.

Photographic observations for the determination of stellar parallaxes were begun at the Dearborn Observatory in 1913. At the present time series of plates have been completed on about forty fields and perhaps as many more fields lack observations at but a single epoch. Measurement has been delayed on account of early difficulties with the measuring machine and its later employment for other purposes. Now however two fields have been measured and reduced and the results are presented to indicate what degree of accuracy may be expected from the Dearborn Observatory plates.

Star	Relative Parallax	Probable Error	Proper Motion	Probable Error	No. of Plates	No. of Comp. Stars
BD 45° (4408) A	+0″.062	±0″.005	0″.897	±0″.008	15	8
OΣ 487 B	+0.086	0.012	0.849	0.018		
C	+0.079	0.012	0.874	0.018		
BD 32° (356)	−0.007	0.004	0.013	0.012	12	8

The star OΣ 477 C is the star noted by Furuhjelm in *A. N.* 4642 as having proper motion equal and parallel to the bright pair.

REPSOLD FILAR MICROMETER, CONSTRUCTED FOR THE 26-INCH EQUATORIAL OF THE NAVAL OBSERVATORY.

By Asaph Hall.

The arrangement of parts is in general the same as shown in Ambronn's *Handbuch der Astronomischen Instrumentenkunde*, Band II, s. 529.

This micrometer is made of iron and steel, with a platinum position circle. The micrometer screw is mounted on one side of the box, with the box screw diagonally opposite the micrometer head. The spring against which the micrometer screw works is on a slide rod parallel to the screw, and presses the end of it against a jewel mounted on a cylindrical plug. The plug can be changed by one-half a revolution, so as to eliminate periodic errors in taking coincidences.

The micrometer screw has a pitch of about 0.04 inches, equivalent to twenty one seconds, approximately. The screw can be read by the usual micrometer heads, or the readings can be printed on a Morse fillet from two type metal wheels which have on them raised figures.

All the micrometer heads, except the printing wheels, are of celluloid, which gives the desired dull surface without a reflection.

The printing wheels are parallel to the other two usual micrometer heads, and move about the micrometer screw as a center, but are fastened to a shoulder that is attached to the micrometer box, so that the printing is done without putting pressure on the screw.

For investigating the micrometer screw the makers have provided a microscope which is attached in place of the eye-piece, together with a suitable arrangement of auxiliary spider lines placed on the movable slide. Thus, the screw can be examined with the micrometer on the instrument. Investigation by this method shows the screw to be an excellent one.

The position circle is approximately 16 inches in diameter, and is divided to 0°.1. It is read by two small microscopes, usually by estimation to 0°.01. If necessary it can be read by the microscopes to 0°.0001. This last reading is ten times more accurate than called for in the specifications drawn by the Naval Observatory, and means, it is supposed, that the circle was copied accurately from the good Repsold original circle. In addition to the fine tangent motion in position angle, there is a large hand ring for rough motion. One small electric light illuminates the two microscopes by which the position circle is read. A second lamp in parallel with this furnishes the bright wire illumination.

On the micrometer is a small crushed carbon rheostat for varying the brightness of the wires. The color of the wires can be changed by the use of different color screens which can be placed about the lamp which furnishes illumination. The current for the lamps comes down the instrument and through contact rings on the micrometer. Extreme care is taken to make the lighting of the threads symmetrical. The bright field illumination has not been changed. That is, light is thrown against the object glass from a small electric lamp mounted inside the tube, near the eye end, just out of the cone of rays. This light comes back from the object glass and gives the bright field.

The eye-piece has a double slide. Therefore, parallels can be taken on the long wires, in which case the star is placed on the wire by means of the slow motion in declination, or the short wires can be used and the star set accurately on one of them by the box screw.

The tail-piece for attaching the new micrometer to the instrument was constructed at the Washington Navy Yard.

THE VARIABLE NEBULA N. G. C. 2261.

By Edwin P. Hubble.

Photographs of N.G.C. 2261, whose nucleus is known as the variable star *R Monocerotis* indicate that pronounced changes occurred in the nebula between March, 1908 and January, 1913. A new feature appeared in the south following portion, and a small stellar mass just south following the nucleus moved in toward the nucleus some 2″.7. No great changes have occurred since. The nebula gives a continuous spectrum and lies in a dark region of the sky connected with the nebulosity around 15 *Monocerotis*.

IRREGULARITIES IN REFRACTION.

By Charles J. Hudson.

In *Allegheny Publications* Vol. 3, No. 1, Dr. Schlesinger confirmed the results of Nusl and Fric in which they showed that there are irregularities in atmospheric refraction with a period of about one minute and an amplitude of about one second of arc.*

For Dr. Schlesinger's experiment some star trails taken with a long focus, stationary, camera were required. As the Thaw telescope was not completed at that time, plates were taken for him with the Yerkes telescope and also with the Mt. Wilson sixty-inch reflector. Trails of the Pleiades with each of these instruments showed that the irregularities occurred simultaneously in stars as far apart as twenty minutes of arc.

In the present experiment an attempt was made to locate the cause of the disturbance.

First, two photographic lenses of seventeen feet focal length were mounted in the meridian so that a star would trail on their plates at the same time. Upon measuring the plates the irregularities were found to have occurred in each trail at the same time. This shows that the cause of the irregularities was not in the tube of the telescope for the cameras were tubeless. Second, the two cameras were so set up that two stars would trail at the same time on the plates—one on one plate and one on the other. Again the irregularities occurred at the same time, this time in stars more than a degree apart. Third, one camera was placed about two hundred feet east and about thirty feet above the other and parallel to it. When the trails were measured it was found that the irregularities did not at all occur at the same time.

The conclusion is that the cause of the irregularities in refraction is near, perhaps within the dome, but certainly not more than one or two hundred feet away.

PROGRESS IN PHOTO-ELECTRIC PHOTOMETRY.

By Jakob Kunz and Joel Stebbins.

During the past year we have made various advances in the production of photo-electric photometers. Some of the disturbing factors, such as dark current, are due to the glass wall of a cell, and by using quartz instead of glass much of the trouble is eliminated.

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* See *Publications of A. A. S.* Vol. 2, 109.

PRELIMINARY MEASURES OF THE SPIRAL NEBULAE N. G. C. 5194 (M 51) AND N. G. C. 4254 (M 99) FOR PROPER MOTION AND ROTATION.

By C. O. Lampland.

The positions of a number of nebulous condensations and nuclei, and stars in the nebulosity and in the immediate vicinity of the spiral nebula N. G. C. 5194 and 4254 were measured by Sir Isaac Roberts on negatives made in 1896 and 1898 with his 20-inch reflector. It was thought worth while to remeasure these positions on negatives made with the 40-inch reflector of the Lowell Observatory, in 1915 and 1916. There are, of course, disadvantages and uncertainties in comparisons of difficult observations of this kind made by different observers from measurements of negatives made with instruments of greatly different focal lengths.

In M 51 Roberts measured 81 points—condensations and nuclei in the nebulous matter, and stars in the nebulosity and near the nebula. After making corrections for the derived value of the motion of the nucleus the residuals for some of the positions are larger than one might judge to be due to uncertainties in the measurements but at present it is a difficult and somewhat uncertain matter to determine how much of this may be due to accidental and systematic errors of observation or to actual changes that may have taken place during the interval between the two series of photographs—eighteen years. For a number of these points, small and well-defined nuclei and nebulous masses, there appears to be evidence of motion, both in position angle and distance, relative to the nucleus. Motion is indicated for several of the small stars in the nebulosity and near the nebula. The yearly proper motion of the central nucleus from a comparison of the two series of photographic measures (Roberts 1898, Lampland 1915, 1916)—making use of twenty comparison stars, assuming that these are not physically connected with the nebula—comes out $+0''.118$ in right ascension and $-0''.017$ in declination. From seven observations of position by earlier observers the resulting values for the components of motion in right ascension and declination are respectively $+0''.118$ and $-0''.007$. But the observations of position are discordant and not much emphasis should be placed on the satisfactory agreement between the values for motion derived from them as compared with the value found from the photographic observations. From direct comparison in position angle of the photographic observations (1898-1915, 1916) the angular motion of the second nucleus, N. G. C. 5195, relative to the central nucleus is approximately $30''$ per year clockwise, or in the direction of decreasing position angle. (It will be remembered that the nebula is a left hand spiral). The differences of the proper motions of the two nuclei as derived from the photographic observations give an angular motion of about 27″ per year clockwise. The positions of the nuclei have been measured by many observers and, from the determinations at present accessible, values for the rotation ranging from 12″ to 20″ per year clockwise were found. The angular motions mentioned would correspond to periods in years as follows: 43000, 48000, 65000, 108000. From the observational data at hand there appears to be no trustworthy indication of a change in distance between the two nuclei. It is hoped that more observational material, earlier photographs, will shortly be available for measurement to decide definitely if possible the questions raised in this comparison of observations.

Measures of several negatives of N. G. C. 4254 (M 99) made with the 40-inch reflector in 1915 and 1916 were compared with the earlier observations by Roberts. Residuals in position angle and distance, for the comparison stars used, agree in indicating a large proper motion for the nucleus, approximately 1/3″ yearly on a great circle in position angle 42°. So large a value must immediately arouse suspicion as to its reality. The different measures of the negatives with the 40-inch reflector are concordant. It is possible that the large value for the motion might be due to systematic errors in the earlier observations. From observations of position of the nucleus by earlier observers and from measures of negatives with the 40-inch reflector, with epochs of observation extending from 1868 to 1916, the resulting components of motion are approximately $+0''.016$ in right ascension and $+0''.043$ in declination. The residuals for many of the nebulous condensations, from the photographic observations of 1896, 1915 and 1916, are large. More observational material will be needed to decide the question of possible motion of the nebulous condensations relative to the nucleus.

THE ECLIPSING VARIABLE SS CAMELOPARDALIS.

By R. J. McDiarmid.

The variable star SS Camelopardalis was discovered by Miss A. J. Cannon of Harvard, with a photographic range of 1.2 magnitude, 9.8 to 11.0.

10,992 photographic measures (16 measures to an observation) were made with a polarizing photometer attached to the 23-inch equatorial of the Princeton Observatory. The observations are best satisfied by the following light elements.

$$\text{J.D. } 2{,}420{,}842.594 + 4^{d}.82438 = 1915 \text{ Dec. } 10^{d}\ 14^{h}\ 21^{m} \text{ G.M.T.} + 4^{d}\ 19^{h}\ 47^{m} - 6^{s}.4.$$

Epoch taken from the middle of primary minimum.

There are two distinct eclipses, primary and secondary. The visual range from maximum to primary minimum is 0.57 magnitude and to secondary minimum, 0.15 magnitude. The stars are ellipsoidal and when correction is made for this, the depths of the minima become 0.485 and 0.082 magnitude respectively. The brightness is greater by about 0.05 magnitude half way between secondary and primary than between primary and secondary. The principal eclipse lasts twenty-one hours and is total for seven hours; the secondary is annular.

The system consists of a large red star of low surface brightness and a smaller white star a little more than one third the diameter of the other, but of five times the surface brightness of the larger star, visually, and twelve times the surface brightness photographically, so that the smaller star is visually the fainter and photographically the brighter of the two.

The density of the large red star is about one two-hundredths and that of the small white star is one-twelfth that of the Sun. The combined spectra is recorded as F?. It is not improbable that the small star is of spectrum A and the larger of spectrum G or redder.

The following table contains the results from the uniform and "darkened" solutions.

TABLE RESULTS.

Elements of System		Uniform	Darkened
Maximum radius of small star	a_2	0.150	0.153
Minimum radius of small star	b_2	0.136	0.144
Maximum radius of large star	a_1	0.446	0.444
Minimum radius of large star	b_1	0.406	0.417
Ratio of the radii of the two stars	k	0.335	0.345
Ratio of the axes of the spheroidal stars	$1+\frac{1}{2}z$	1.038	1.054
The least apparent distance of centres	$\cos i$	0.2024	0.2305
Inclination of orbit	i	78°.3	76°.0
Eccentricity or orbit	$e \cos \omega$	—0.03	
Maximum percentage loss of light at primary minimum	α_{op}	1.00	1.00
Maximum percentage loss of light at secondary minimum	α_{os}	1.00	*1.096
The light of the bright star } visual	L_b	0.6397	0.6397
The light of the faint star	L_f	0.3603	0.3603
Ratio of the surface brightness of the two stars (visual)	$\frac{J_b}{J_f}$	5.02	4.74
The light of bright star } photographic	L_b	0.583	
The light of faint star	L_f	0.417	
Ratio of surface brightness of the two stars (photographic)	$\frac{J_b}{J_f}$	12.2	11.7
Most probable density of smaller star	ρ_b	0.094	0.078
Most probable density of larger star	ρ_f	0.0050	0.0046
Hypothetical radius of brighter star in terms of solar radius		2.32	2.32
Hypothetical parallax			0.0009
Distance in light years from the galactic plane			1700
Distance in light years projected on galactic plane			3200
Visual magnitude of system			10.15
Visual magnitude of big star End on			10.65
Visual magnitude of small star End on			11.26
Photographic magnitude of system			9.9
Photographic magnitude of big star End on			10.86
Photographic magnitude of small star End on			10.48

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* Expressed in terms of the light lost at internal tangency.

SUMMARY OF THE SPROUL OBSERVATORY PARALLAX WORK.

By John A. Miller.

The paper was a resumé of the work done at Sproul Observatory on Stellar Parallax. The parallax of sixty-four objects has been determined. Twenty of these are visual binaries whose orbits are well determined. Five are spectroscopic binaries. One, ε *Hydrae*, is a spectroscopic and a visual binary. The remainder are nearly equally distributed among stars whose hypothetical parallax is large, stars of large proper motion, and stars with two or more discordant determinations. The average of probable error of all the determinations is about 0.010. The results for 42 objects are given here, the visual binaries are discussed in the paper by Miss Steele.

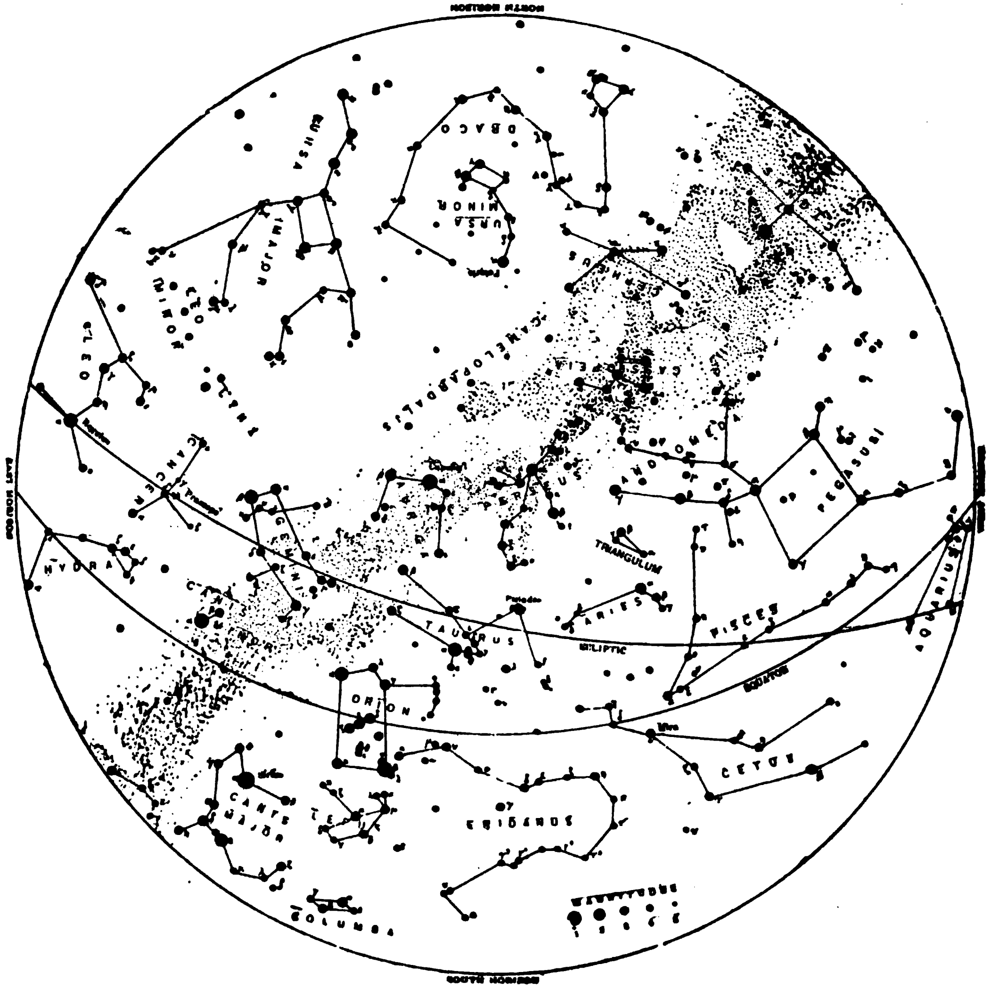
Star	R.A.		Decl.			π
	h	m	°	′	″	″
ε Andromedae	0	33.3	+28	46	+0.096	±0.015
μ Andromeda	0	51.2	+37	57	+0.032	±0.013
θ Cassiopeiae	1	5.0	+54	37	−0.003	±0.003
Σ 228	2	7.6	+47	1	+0.069	±0.009
ι Persei	3	1.8	+49	14	+0.120	±0.012
Greenwich 284	3	56.5	+35	2	+0.072	±0.002
0Σ (App.) 54	4	36.2	+22	46	−0.053	±0.009
τ Tauri	4	36.2	+22	46	+0.012	±0.013
Weisse 4^h, 1189	4	55.9	− 5	52	+0.111	±0.019
λ Aurigae	5	12.1	+40	1	+0.069	±0.008
BD −3° 1118	5	26.4	−3	42	−0.020	±0.018
ϕ_2 Orionis	5	31.4	+9	15	+0.027	±0.006
0Σ 149	6	30.2	+27	22	+0.048	±0.013
Lalande 13198	6	45.7	− 0	25	+0.015	±0.008
Nova Gemin. No. 2, 1912	6	49.3	+32	15	−0.019	±0.035
ζ Geminorum	6	58.1	+20	41.8	+0.017	±0.019
Lalande 13849	7	4.2	+21	25	+0.019	±0.010
Procyon	7	34.1	+ 5	29	+0.287	±0.012
13 Canis Minoris	7	57.1	+ 2	36	+0.035	±0.008
β 581	7	58.8	+12	35	+0.082	±0.009
Lalande 16304	8	13.7	−12	18	+0.075	±0.007
10 Ursae Majoris	8	54.2	+42	11	+0.086	±0.015
11 Leonis Minoris	9	29.7	+36	16	+0.220	±0.022
Bradley 1433	10	16	+41	44	+0.080	±0.007
36 Ursae Majoris	10	24	+56	30	+0.090	±0.013
Lalande 21185	10	57.9	+36	38	+0.443	±0.010
β Leonis	11	44	+15	8	+0.116	±0.013
33 Virginis	12	41.3	+10	6	−0.003	±0.008
μ Bootis	15	20.7	+37	44	+0.033	±0.029
Σ 2107	16	48	+28	50	+0.006	±0.006
u Herculis	17	13.6	+33	12	−0.031	±0.007
26 Draconis	17	34	+61	58	+0.080	±0.016
δ Cygni	19	41.9	+44	56	+0.049	±0.008
BD 44° 3242	19	42.8	+44	51.8	−0.012	±0.007
X Cygni	20	39.5	+35	14	+0.000	±0.008
61 Cygni	21	2.4	+38	15	+0.301	±0.022
	21	25.4	+45	1.9	−0.006	±0.009
g Cygni	21	25.8	+46	6	+0.027	±0.008
	21	26.8	+46	5.7	+0.002	±0.027
ι Pegasi	22	2.4	+24	51	+0.063	±0.011
ε Cephei	22	11.3	+56	33	+0.30	±0.008
Bradley 3077	23	8.5	+56	37	+0.181	±0.009

(*To be continued.*)

PLANET NOTES FOR JANUARY, 1917.

The sun will move northward 5° during the month, from — 23° to — 17°. It will move in an easterly direction from the constellation of Sagittarius into Capricornus through a region in which there are no particularly bright stars. A partial eclipse of the sun will occur on January 22. It will not be visible in the western hemisphere. There will be a total eclipse of the moon January 7. The data are as follows:

			h	m		
Moon enters penumbra	January 7	at	10	35.7	P.M.	C.S.T.
Moon enters shadow	7	"	11	50.4	P.M.	"
Total eclipse begins	8	"	1	0.4	A.M.	"
Middle of eclipse	8	"	1	44.6	A.M.	"
Total eclipse ends	8	"	2	28.8	A.M.	"



THE CONSTELLATIONS AT 9:00 P. M. JANUARY 1.

The phases of the moon for January are as follows:

			h	m		
Full Moon	January 8	at	1	42	A.M.	C.S.T.
Last Quarter	15	"	5	42	A.M.	"
New Moon	22	"	1	40	A.M.	"
First Quarter	29	"	7	2	P.M.	"

Mercury will reach a point of greatest elongation on January 2. On the sixteenth of the month its stellar magnitude will be + 2.1. At this time it may be seen in the twilight about 4° north of where the sun sets. It will be found in the constellation Sagittarius.

Venus may be seen in the morning sky in the constellation Ophiuchus.

Mars will not be visible during the month.

Jupiter will still be in a position for evening observation. It will have a westward motion in the constellation Pisces.

Saturn will be on the meridian at midnight on the fifteenth of the month. At the beginning of the month it will be found near the western boundary of Cancer.

Uranus will not be visible.

Neptune at the beginning of the month may be found with the aid of a smal telescope about 30^m east of Saturn near the eastern boundary of Gemini.

Phenomena of Jupiter's Satellites.

[Visible at Washington.]

CENTRAL STANDARD TIME.

1917	h	m		
Jan. 1	5	7	II	Ec. R.
2	11	34	I	Tr. I.
3	8	53	I	Oc. D
4	6	2	I	Tr. I.
	7	20	I	Sh. I.
	8	12	I	Tr. E.
	9	29	I	Sh. E.
5	5	4	III	Oc. D.
	6	51	I	Ec. R.
	7	4	III	Oc. R.
	10	33	III	Ec. D.
6	8	22	II	Tr. I.
	10	56	II	Tr. E.
	11	2	II	Sh. I.
8	5	6	II	Oc. R.
	5	11	II	Ec. D.
	7	44	II	Ec. R.
10	10	47	I	Oc. D.
11	7	57	I	Tr. I.
	9	16	I	Sh. I.
	10	6	I	Tr. E.
12	5	16	I	Oc. D.
	8	47	I	Ec. R.
	9	0	III	Oc. D.
	11	2	III	Oc. R.
13	5	54	I	Sh. E.
	10	56	II	Tr. I.
15	5	5	II	Oc. D.
	7	42	II	Oc. R.
	7	49	II	Ec. D.
	10	21	II	Ec. R.
Jan. 16	4	41	III	Sh. I.
	6	20	III	Sh. E.
17	5	29	II	Sh. E.
18	9	52	I	Tr. I.
19	7	11	I	Oc. D.
	10	43	I	Ec. R.
20	5	41	I	Sh. I.
	6	30	I	Tr. E.
	7	49	I	Sh. E.
21	5	12	I	Ec. R.
22	7	43	II	Oc. D.
	10	20	II	Oc. R.
	10	26	II	Ec. D.
23	5	8	III	Tr. E.
	8	44	III	Sh. I.
	10	22	III	Sh. E.
24	5	29	II	Tr. E.
	5	36	II	Sh. I.
	8	7	II	Sh. E.
26	9	8	I	Oc. D.
27	6	17	I	Tr. I.
	7	36	I	Sh. I.
	8	27	I	Tr. E.
	9	45	I	Sh. E.
	7	7	I	Ec. R.
29	10	22	II	Oc. D.
30	6	13	III	Tr. I.
	9	16	III	Tr. E.
31	5	35	II	Tr. I.
	8	10	II	Tr. E.
	8	14	II	Sh. I.

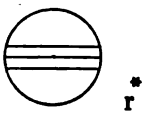
Note:—I., denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

Satellites of Jupiter, January, 1917.

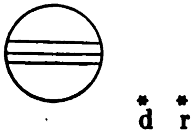
GREENWICH MEAN TIME.

Phases of the Eclipses of the Satellites for an Inverting Telescope.

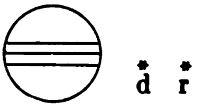
I.



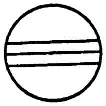
III.



II.



V. No Eclipse



Configurations at 14h 10m for an Inverting Telescope.

Day	West		East
1	4· ·1	O	$^{3}:_{2}$
2	·4 3·	O	1· 2·
3	·4 ·3 2· ·	O	1
4	O 1· ·4 ·3 ·2	O	
5	·4	O$_{.3}$	·1 ·2
6	1· ^{2}	O	· ·4 ·3
7	·2	O	·1 ·4 3·
8	·1	O	·2 3· ·4
9	3·	O	1· 2· ·4
10	3· 2· ·1	O	4·
11	O 1· ·3 ·2	O	4·
12	·	O	3 ·2 4· ·1 ●
13	1·	O	2· $^{4}:_{3}$
14	2· 4	O	· ·1 3·
15	4· 1·	O	3· ·2 ●
16	4. 3·	O	1· 2·
17	4· 3· $^{2}:_{1}$	O	
18	4· ·3 ·2	O	1·
19	·4 ·3	O	·2 ·1 ●
20	·4 1·	O	2· ·3
21	·4 2·	O	·1 ·3
22	$^{1}:_{4}$	O	3· ·2 ●
23	3·	O	$^{1}:_{4}$ 2·
24	3· ·12·	O	·4
25	·3 ·2	O	1· ·4
26	·3 ·	O	1 ·2 .4
27	O 1·	O	2· .3 4·
28	2·	O	·1 ·3 4·
29	1· ·2	O	3· 4·
30	O 3·	O	·1 $^{4}:_{2}$
31	O 2· 3· ·1 4·	O	

Occultations Visible at Washington.

Date 1917		Star's Name	Magnitude	IMMERSION. Washington M.T.		IMMERSION. Angle f'm N.	EMERSION. Washington M.T.		EMERSION. Angle f'm N.	Duration	
				h	m	°	h	m	°	h	m
Jan.	3	66 Arietis	6.1	4	16	108	5	14	207	0	59
	3	23 Tauri	4.3	15	06	12	15	20	345	0	13
	6	5 Geminorum	5.9	4	44	152	5	09	202	0	25
	7	44 Geminorum	5.9	5	21	125	6	12	240	0	50
	7	δ Geminorum	3.5	14	39	106	15	53	302	1	14
	7	149 B.Geminorum	6.4	18	33	45	18	56	354	0	23
	7	63 Geminorum	5.3	18	55	52	19	23	346	0	28
	8	85 Geminorum	5.2	5	32	91	6	29	285	0	57
	8	217 B.Geminorum	6.3	8	11	57	9	03	328	0	52
	9	54 Cancri	6.3	10	21	169	11	06	236	0	45
	10	ξ Leonis	5.1	7	38	165	8	10	231	0	32
	11	155 B. Leonis	6.5	11	59	141	13	18	286	1	19
	14	q Virginis	5.3	10	55	88	11	47	330	0	52
	18	85 B. Scorpii	6.0	15	16	71	16	05	322	0	50
	26	19 Piscium	5.4	6	25	70	7	30	229	1	05
	29	26 Arietis	6.2	10	37	55	11	35	283	0	58
	30	66 Arietis	6.1	12	39	124	13	24	229	0	45

VARIABLE STARS.

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1917. January							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Cassiop.	0	09.8	+57	52	9.3— 9.9	4	1.7	3	16;	11	19;	19	22;	28	1
RR Ceti	1	27.0	+ 0	50	8.3— 9.0	0	13.3	3	3;	10	21;	18	15;	26	9
RW Cassiop.	1	30.7	+57	15	8.9—11.0	14	19.2	7	2			21	21		
V Arietis	2	09.6	+11	46	8.3— 9.0	0	23.8	5	15;	13	14;	21	12;	29	11
SU Cassiop.	2	43.0	+68	28	6.5— 7.0	1	22.8	6	23;	14	19;	22	14;	30	9
TU Persei	3	01.8	+52	49	11.4—12.2	0	14.6	1	2;	8	9;	22	23;	30	5
RW Camelop.	3	46.2	+58	21	8.2— 9.4	16	00.0	4				20			
SX Persei	4	10.2	+41	27	10.4—11.2	4	07.0	5	16;	14	6;	22	20;	31	10
SV Persei		42.8	+42	07	8.8— 9.6	11	03.1	7	4;	18	7;	29	11		
RX Aurigae	4	54.5	+39	49	7.2— 8.1	11	15.0	4	18;	16	9;	28	0		
SX Aurigae	5	04.6	+42	02	8.0— 8.7	1	12.8	9	7;	16	23;	24	15		
SY Aurigae		05.5	+42	41	8.4— 9.5	10	03.3			10	10;	20	14;	30	17
Y Aurigae		21.5	+42	21	8.6— 9.6	3	20.6	3	7;	11	20;	18	18;	26	11
RZ Gemin.	5	56.6	+22	15	9.1—10.0	5	12.7	3	21;	14	22;	25	23;	31	12
RS Orionis	6	16.5	+14	44	8.2— 8.9	7	13.6	4	4;	11	17;	19	7;	26	20
T Monoc.		19.8	+ 7	08	5.7— 6.8	27	00.3					19	21		
RT Aurigae		23.0	+30	33	5.1— 6.0	3	17.5	8	1;	15	12;	22	23;	30	10
RZ Camelop.		23.7	+67	06	11.0—13.0	0	11.5	4	3;	11	8;	18	14;	25	18
W Gemin.		29.2	+15	24	6.7— 7.5	7	22.0	8	19;	16	17;	24	14		
ζ Gemin.	6	58.2	+20	43	3.7— 4.3	10	03.7	2	1;	12	5;	22	8		
RU Camelop.	7	10.9	+69	51	8.5— 9.8	12	06.5			21	0				
RR Gemin.	7	15.2	+31	04	10.0—11.5	0	09.5	4	4;	12	2;	20	1;	28	0

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1916. January							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
V Carinae	8	26.7	−59	47	7.4— 8.1	6	16.7	4	3;	10	20;	24	5;	30	22
T Velorum	8	34.4	−47	01	7.6— 8.5	4	15.3	1	1;	10	7;	19	14;	28	21
V Velorum	9	19.2	−55	32	7.5— 8.2	4	08.9	8	2;	16	19;	25	13		
RR Leonis	10	02.1	+24	29	9.1–10.1	0	10.9	1	9;	8	4;	14	23;	28	13
SU Draconis	11	32.2	+67	53	8.9— 9.6	0	15.8	6	22;	13	12;	20	3;	26	17
S Muscae	12	07.4	−69	36	6.4— 7.3	9	15.8	9	15;	19	7;	28	23		
SW Draconis		12.8	+70	04	8.8— 9.6	0	13.7	7	20;	15	19;	23	19;	31	18
T Crucis		15.9	−61	44	6.8— 7.6	6	17.6	6	10;	13	3;	19	21;	26	15
R Crucis		18.1	−61	04	6.8— 7.9	5	19.8	1	21;	13	12;	25	4;	31	0
S Crucis	12	48.4	−57	53	6.5— 7.6	4	16.6	2	15;	12	1;	21	10;	26	2
W Virginis	13	20.9	−2	52	8.7—10.4	17	06.5			11	4;	28	11		
SS Hydrae		25.0	−23	08	7.4— 8.1	8	4.8	3	19;	12	0;	20	5;	28	10
RV Urs. Maj.	13	29.4	+54	31	9.2— 9.9	0	11.2	2	11;	9	11;	23	12;	30	13
ST Virginis	14	22.5	−0	27	10.3—11.4	0	09.9	1	13;	9	18;	17	23;	26	4
V Centauri		25.4	−56	27	6.4— 7.8	5	11.9	4	16;	10	14;	21	4;	26	16
RS Bootis		29.3	+32	11	8.9—10.0	0	09.1	2	11;	10	0;	17	13;	25	2
RU Bootis	14	41.5	+23	44	12.8–14.3	0	11.9	2	7;	9	17;	24	13;	31	23
R Triang. Austr.	15	10.8	−66	08	6.7— 7.4	3	09.3	1	22;	8	17;	22	7;	29	2
S Triang. Austr.	15	52.2	−63	29	6.4— 7.4	6	07.8	3	17;	10	0;	22	16;	29	0
S Normae	16	10.6	−57	39	6.6— 7.6	9	18.1	3	1;	12	19;	22	13		
RW Draconis		33.7	+58	03	9.6—10.8	0	10.6	5	6;	14	3;	23	0;	30	20
RV Scorpii	16	51.8	−33	27	6.7— 7.4	6	01.5	4	18;	10	19;	22	22;	28	23
X Sagittarii	17	41.3	−27	48	4.4— 5.0	7	00.3	3	10;	10	10;	24	11;	31	11
Y Ophiuchi		47.3	−6	07	6.1— 6.5	17	02.9			14	17;			31	20
W Sagittarii	17	58.6	−29	35	4.3— 5.1	7	14.3	7	0;	14	14;	22	4;	29	18
Y Sagittarii	18	15.5	−18	54	5.4— 6.2	5	18.6	2	4;	7	22;	19	12;	31	1
U Sagittarii		26.0	−19	12	6.5— 7.3	6	17.9	5	16;	12	9;	19	3;	25	21
Y Scuti	18	32.6	−8	27	8.7— 9.2	10	08.3	3	2;	13	10;	23	19		
Y Lyrae		34.2	+43	52	11.3—12.3	0	12.1	2	13;	8	14;	20	16;	26	16
RZ Lyrae		39.9	+32	42	9.9—11.2	0	12.3	6	16;	12	19;	25	2;	31	5
RT Scuti		44.1	−10	30	9.1— 9.7	0	11.9	3	6;	9	5;	21	2;	27	1
κ Pavonis	18	46.6	—67	22	3.8— 5.2	9	02.2	9	22;	19	0;	28	2		
U Aquilae	19	24.0	−7	15	6.2— 6.9	7	00.6	3	23;	10	23;	19	0;	25	0
XZ Cygni		30.4	+56	10	8.6— 9.3	0	11.2	3	4;	10	4;	24	4;	31	4
U Vulpec.		32.2	+20	07	6.5— 7.6	7	23.5	1	16;	9	16;	17	15;	25	15
SU Cygni		40.8	+29	01	6.2— 7.0	3	20.3	3	15;	11	7;	18	23;	26	16
η Aquilae		47.4	+0	45	3.7— 4.5	7	04.2	6	17;	13	22;	21	2;	28	6
S Sagittae		51.5	+16	22	5.6— 6.4	8	09.2	8	4;	16	14;	24	23		
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	1	5:	7	13;	20	4;	26	11
X Cygni	20	39.5	+35	14	6.0— 7.0	16	09.3	5	11			21	20		
T Vulpec.		47.2	+27	52	5.5— 6.1	4	10.5	1	15;	10	12;	19	9;	28	6
WY Cygni		52.3	+30	03	9.6–10.4	0	13.5	6	2;	13	20;	20	13;	27	6
RV Capric.		55.9	−15	37	9.2–10.1	0	10.7	5	18;	12	11;	18	4;	25	22
TX Cygni	20	56.4	+42	12	8.5– 9.7	14	17.4			10	20;	25	14		
VY Cygni	21	00.4	+39	34	8.8– 9.5	7	20.6	6	20;	14	16;	22	13;	30	10
SW Aquarii		10.2	—0	20	9.9–10.8	0	11.0	7	13;	14	10;	21	8;	28	5
VZ Cygni	21	47.7	+42	40	8.2– 9.2	4	20.7	5	19;	10	16;	20	9;	30	2
Y Lacertae	22	05.2	+50	33	9.1– 9.6	4	07.8	2	19;	11	11;	20	2;	28	18
δ Cephei		25.5	+57	54	3.7– 4.6	5	08.8	3	14;	8	23;	19	16;	30	10
Z Lacertae		36.9	+56	18	8.2– 9.0	10	21.1	9	23;	20	20;	31	17		
RR Lacertae		37.5	+55	55	8.5– 9.2	6	10.1	3	15;	10	0;	22	20;	29	6
V Lacertae	22	44.5	+55	48	8.5– 9.5	4	23.6	2	12;	7	12;	17	11;	27	10
X Lacertae		45.0	+55	54	8.2— 8.6	5	10.7	2	11;	7	21;	18	18;	29	16
SW Cassiop.	23	03.7	+58	11	9.2— 9.7	5	10.6	1	23;	12	20;	23	17;	29	4
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	1	7;	7	14;	13	21;	26	12
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4			11	8;	23	11		
V Cephei	23	51.7	+82	38	6.0—7.0	0	23.6	1	20;	11	20;	21	19;	31	18

Minima of Variable Stars of Short Period.

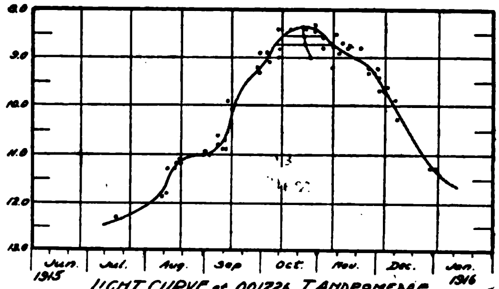
[Calculated by Lois N. Wilson at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1917 January							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.8			23	8				
RT Sculptor.		31.5	—26	13	9.6—10.5	0	12.3	4	12;	12	4;	19	20;	27	12
UU Androm.		38.5	+30	24	10.7—11.9	1	11.7	10	8;	17	19;	25	5		
U Cephei	0	53.4	+81	20	7.0— 9.0	2	11.8	8	5;	15	16;	23	4;	30	15
Z Persei	2	33.7	+41	46	9.4—12	3	01.4	1	3;	7	6;	13	8;	25	14
TW Cassiop.		37.6	+65	19	8.2— 9.0	1	10.3	4	9;	11	12;	18	16;	25	19
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	7	17;	14	13;	21	10;	28	7
RZ Cassiop.		39.9	+69	13	6.9— 8.1	1	04.7	8	4;	15	19;	22	23;	30	3
TX Cassiop.		44.4	+62	22	9.4—10.1	2	22.2	1	1;	9	20;	18	15;	27	9
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	7	15;	15	13;	23	12;	31	11
RX Cassiop.	2	58.8	+67	11	8.6— 9.1	32	07.6							30	17
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	3	2;	14	14;	20	7;	31	19
RT Persei		16.7	+46	12	9.5—11.5	0	20.4	4	1;	10	20;	17	15;	31	5
λ Tauri		55.1	+12	12	3.3— 4.2	3	22.9	1	3;	9	0;	16	22;	24	20
RW Tauri	3	57.8	+27	51	7.1—<11	2	18.5	0	22:	9	6;	17	13;	25	20
RV Persei	4	04.2	+33	59	9.5—11.0	1	23.4	5	14;	13	11;	21	9;	29	6
RW Persei		13.3	+42	04	8.8—11.0	15	04.8	3	10;	16	14;	29	19		
SZ Tauri		31.4	+18	20	7.2— 7.7	3	03.6	1	6;	10	17;	20	3;	29	14
RS Cephei	4	48.6	+80	06	9.5—12.0	12	10.1			10	2;	22	12		
TT Aurigae	5	02.8	+39	27	7.8— 8.7	0	16.0	2	14;	9	6;	22	14;	29	6
RY Aurigae		11.5	+38	13	10.7—11.7	2	17.5	2	18;	8	5;	19	3;	27	8
RZ Aurigae		42.9	+31	40	10.6—13.3	3	00.3	2	16;	8	16;	20	17;	26	18
SV Tauri		45.8	+28	05	9.4—11.0	2	04.0	2	15;	11	7;	19	23;	28	15
Z Orionis		50.2	+13	40	9.7—10.7	5	04.9	2	2;	12	12;	22	22		
SV Gemin.		54.6	+24	28	9.8—<11	4	00.2	5	23;	13	23;	21	23;	30	0
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	5	2;	10	19;	22	6;	28	0
U Columbae	6	11.2	—33	03	9.2—10.0	2	19.2	5	5;	10	19;	22	0;	27	15
SX Gemin.		22.0	+20	37	10.8—11.5	1	08.8	5	18;	13	23;	22	4;	30	8
RW Monoc.		29.3	+ 8	54	9.0—10.8	1	21.7	4	14;	12	5;	19	20;	27	10
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0			12	20;	25	1		
RU Monoc.	6	49.4	— 7	28	9.8—10.5	0	21.5	6	21;	14	1;	21	5;	28	10
R Can. Maj.	7	14.9	—16	12	5.8— 6.4	1	03.3	1	22;	8	18;	22	9;	29	5
RY Gemin.		21.7	+15	52	8.9—<10	9	07.2	4	7;	13	14;	22	21		
Y Camelop.		27.6	+76	17	9.5—12	3	07.3	2	15;	9	6;	22	11;	29	2
TX Gemin.		30.3	+17	8	10.0—11.9	2	19.2	5	10;	13	20;	22	5;	30	15
RR Puppis		43.5	—41	08	9.4—10.7	6	10.3	4	9;	10	19;	23	16;	30	2
V Puppis	7	55.4	—48	58	4.1— 4.8	1	10.9	2	20;	10	2;	24	15;	31	22
X Carinae	8	29.1	—58	53	7.9— 8.7	0	13.0	3	18;	11	21;	20	0;	28	2
S Cancri	8	38.2	+19	24	8.2—10	9	11.6	2	6;	11	18;	21	5;	30	17
RX Hydrae	9	00.8	— 7	52	9.1—10.5	2	6.8	7	10;	14	7;	21	3;	27	23
S Velorum		29.4	—44	46	7.8— 9.3	5	22.4	4	15;	10	13;	22	10;	28	8
Y Leonis	9	31.1	+26	41	9.3—11.2	1	16.5	2	7;	9	1;	22	13;	29	7
RR Velorum	10	17.8	—41	36	10.0—10.9	1	20.5	4	13;	11	23;	19	9;	26	19
SS Carinae	10	54.2	—61	23	12.2—12.8	3	07.2	1	17;	8	8;	21	13;	28	3
ST Urs. Maj.	11	22.4	+45	44	6.7— 7.2	8	19.2	9	14;	18	10;	27	5		
RW Urs. Maj.		35.4	+52	34	10.3—11.4	7	07.9	8	4;	15	12;	22	20;	30	4
Z Draconis	11	39.8	+72	49	9.9—13.6	1	08.6	3	10;	10	5;	23	19;	30	14
RZ Centauri	12	55.6	—64	05	8.5— 8.9	1	21.0	7	22;	15	10;	22	22;	30	10
RS Can. Ven.	13	06.3	+36	28	7.5—12.5	4	19.2	8	19;	18	9;	27	23		
SS Centauri	13	07.2	—63	37	8.8—10.4	2	11.5	4	21;	12	7;	19	18;	27	4
δ Librae	14	55.6	— 8	07	4.8— 6.2	2	07.9	3	12;	10	11;	24	11;	31	10

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of minima in 1917 January							
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
U Coronae	15	14.1	+32	01	7.6— 8.7	3	10.9	6	21;	13	18;	20	16;	27	14
TW Draconis		32.4	+64	14	7.3— 8.9	2	19.4	1	7;	9	17;	18	3;	26	13
SS Librae	15	43.4	—15	14	9.3—11.5	0	18.4	2	14;	10	6;	17	22;	25	13
SW Ophiuchi	16	11.1	— 6	44	9.2—10.0	2	10.7	1	21;	9	6;	23	22;	31	6
SX Ophiuchi		12.6	— 6	25	10.5—11.2	2	01.5	5	7;	13	13;	21	20;	30	2
R Arae		31.1	—56	48	6.8— 7.9	4	10.2	9	3;	18	0;	26	20		
TT Herculis	16	49.9	+17	00	8.9— 9.3	20	18.1			16	15;	29	17		
TU Herculis	17	09.8	+30	50	9.5—12	2	06.4	1	1;	7	21;	21	11;	28	6
U Ophiuchi		11.5	+ 1	19	6.0— 6.7	0	20.1	3	3;	11	12;	19	21;	28	7
u Herculis		13.6	+33	12	4.6— 5.4	2	01.2	6	7;	12	11;	18	14;	24	18
TX Herculis		15.4	+42	00	8.3— 9.0	1	00.7	2	3;	9	8;	23	18;	30	23
RV Ophiuchi		29.8	+ 7	19	9. —12	3	16.5	3	1;	10	10;	17	19;	25	4
SZ Herculis		36.0	+33	01	9.5—10.3	0	19.6	6	20;	15	0;	23	4;	31	9
TX Scorpii		48.6	—34	13	7.5— 8.2	0	22.6	2	2;	9	15;	17	4;	24	17
UX Herculis		49.7	+16	57	8.8—10.5	1	13.2	4	6;	11	23;	19	17;	27	11
Z Herculis		53.6	+15	09	7.1— 7.9	3	23.8	6	14;	14	13;	22	13;	30	13
WX Sagittae		53.6	—17	24	9.2—10.8	2	03.1	4	20;	13	9;	21	21;	30	10
WY Sagittae	17	54.9	—23	1	9.5—10.6	4	16.0	7	17;	17	1;	26	9		
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	7	23;	18	7;	28	16		
RS Sagittarii		11.0	—34	08	5.9— 6.3	2	10.0	2	11;	9	17;	24	5;	31	10
V Serpentis		11.1	−15	34	9.5−11.1	3	10.9	4	9;	11	7;	18	5;	25	3
RZ Scuti		21.1	− 9	15	7.4— 8.3	15	03.2			14	10			29	13
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	6	19;	13	23;	21	3;	28	7
RX Herculis		26.0	+12	32	7.0— 7.6	0	21.3	7	5;	14	7;	21	10;	28	13
SX Sagittarii		39.7	—30	36	8.7— 9.8	2	01.8	9	5;	17	13;	25	20		
RR Draconis		40.8	+62	34	9.3—13	2	19.9	1	20;	10	8;	18	19;	27	7
RS Scuti		43.7	—10	21	9.3—10.3	0	15.9	1	16;	8	8;	21	15;	28	6
β Lyrae		46.4	+33	15	3.4— 4.1	12	21.8	2	6;	15	4;	28	2		
U Scuti	18	48.9	—12	44	9.1— 9.6	0	22.9	3	12;	11	3;	18	19;	26	10
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.4	2	23;	10	13;	18	3;	25	16
RV Lyrae		12.5	+32	15	11. —12.8	3	14.4	7	16;	14	21;	22	1;	29	6
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	4	3;	13	2;	22	1;	31	0
U Sagittae		14.4	+19	26	6.5— 9.0	3	09.1	5	11;	12	5;	19	0;	25	18
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	4	17;	12	2;	19	10;	26	19
TT Lyrae		24.3	+41	30	9.3—11.6	5	05.8	3	19;	9	1;	19	12;	30	0
UZ Draconis		26.1	+68	44	9.0— 9.8	1	15.1	3	17;	10	6;	23	7;	29	20
SY Cygni	19	42.7	+32	28	10 —12	6	00.2	4	18;	10	18;	22	18;	28	18
WW Cygni	20	00.6	+41	18	9.3—13.4	3	07.6	2	7;	8	22;	22	5;	28	20
SW Cygni		03.8	+46	01	9. —11.7	4	13.8	1	7;	10	11;	19	14;	28	18
VW Cygni		11.4	+34	12	9.8—11.8	8	10.3	9	5;	17	15;	26	2		
RW Capric.		12.2	—17	59	8.8—10.6	3	09.4	2	4;	8	23;	22	12;	29	7
UW Cygni		19.6	+42	55	10.5—10.8	3	10.8	7	2;	14	0;	20	22;	27	19
V Vulpec.		32.3	+26	15	8.2—9.8	37	19.0					19	12		
W Delphini		33.1	+17	56	9.4—12.1	4	19.4	6	14;	16	4;	25	19		
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	3	18;	12	22;	22	3;	31	8
Y Cygni		48.1	+34	17	7.1— 7.9	1	12.0	2	6;	9	18;	17	6;	24	17
WZ Cygni		49.3	+38	27	9.9—10.8	0	14.0	2	5;	9	20;	17	10;	25	0
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	7	19;	17	21;	28	0		
VV Cygni	21	02.3	+45	23	12.1—13.8	1	11.4	7	11;	14	20;	22	5;	29	15
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	9	12;	19	5;	28	21		
RY Aquarii		14.8	—11	14	8.8—10.4	1	23.2	6	10;	14	7;	22	3;	30	0
RT Lacertae	21	57.4	+43	24	9.1—10.5	5	01.7	1	8;	11	11;	21	15;	31	18
UZ Cygni		55.2	+43	52	8.9—11.6	31	07.3					24	6		
RW Lacertae	22	40.6	+49	08	10.2—11.2	5	04.4	5	6;	15	15;	20	20;	31	5
TT Androm.	23	08.7	+45	36	11.3—12.6	2	18.3	1	11;	9	18;	18	1;	26	8
Y Piscium		29.3	+ 7	22	9.0—12.0	3	18.4	7	7;	14	20;	22	8;	29	21
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	5	9;	13	15;	21	21;	30	3
SX Cassiop.	0	05.5	+54	20	8.6— 9.4	36	13.7			10	16				

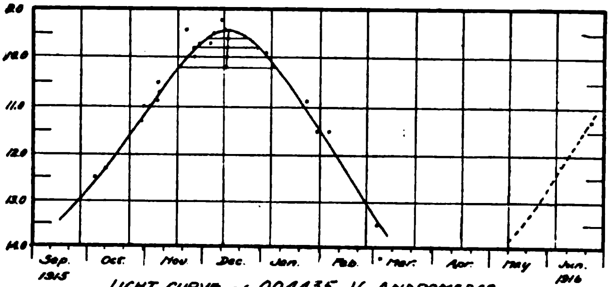


LIGHT CURVE of 001726 T ANDROMEDAE

Maximum Oct. 23, 1915—J.D. 2420794; mag 8.4.

From observations by Amer. Assn. of Var. Star Observers.

C.B.L.
Cinti, O.

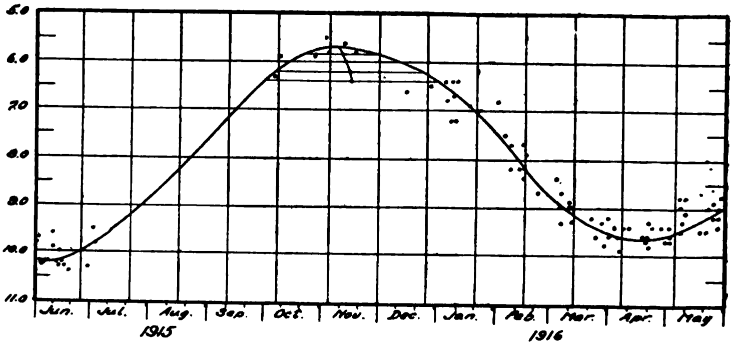


LIGHT CURVE of 004435 V ANDROMEDAE

Maximum Dec. 13, 1915, (J.D. 2420845); Magnitude 9.4

Observations by Amer. Assn. of Var. Star Observers.

Chas. B Lindsley
Cinti, O.



LIGHT CURVE of 194211 R LEONIS

Maximum Nov. 8, 1915, J.D. 2420810; Mag. 5.7.

Observations by Amer. Assn of Var. Star Observers.

Chas. B. Lindsley
Cinti, O.

COMET AND ASTEROID NOTES.

New Comet 1916 *c* (Metcalf).—A telegram received November 24, from Harvard College Observatory, announces the discovery of a very faint comet on November 21, by Rev. Joel Metcalf of Winchester, Mass. The position given is

Nov. 21.5673 Gr.M.T. R.A. $3^h\ 38^m\ 00^s.5$, Decl. + 18° 32′ 50″.

Daily motion $11^s.5$ west and 35′.4 south. Appearance starlike.

In the Harvard College Observatory Bulletin 618 the following approximate positions are given:

Gr.M.T		α			δ		Observer	Place
		h	m	s	°	′		
Nov.	21.5673	3	38	00.5	+ 18	32.8	Metcalf	Winchester
	22.5396	3	37	49.3	+ 17	58.4	"	"

It is also stated there that the comet is very faint, but eight photographic images have been obtained. This is the fourth comet discovered by Mr. Metcalf.

At Northfield the comet was searched for in vain, both with the 16-inch telescope and the 6-inch photographic camera, on the night of November 24.

Ephemeris of Comet *b* 1916 (Wolf).

1917 Gr.M.T.		True α			True δ			log Δ	Br.
		h	m	s	°	′	″		
Jan.	1.5	16	04	36.5	−6	04	58		
	2.5		06	29.1		05	00	0.5192	5.03
	3.5		08	22.2		04	55		
	4.5		10	15.7		04	43	0.5146	5.20
	5.5		12	09.7		04	23		
	6.5		14	04.1		03	56	0.5099	5.39
	7.5		15	58.9		03	21		
	8.5		17	54.2		02	39	0.5052	5.58
	9.5		19	49.9		01	49		
	10.5		21	46.1	−6	00	51	0.5004	5.79
	11.5		23	42.7	−5	59	45		
	12.5		25	38.8		58	31	0.4955	6.00
	13.5		27	37.3		57	09		
	14.5		29	35.3		55	39	0.4906	6.23
	15.5		31	33.7		54	00		
	16.5		33	32.5		52	13	0.4856	6.46
	17.5		35	31.8		50	17		
	18.5		37	31.5		48	13	0.4806	6.71
	19.5		39	31.6		46	00		
	20.5		41	32.2		43	37	0.4754	6.96
	21.5		43	33.2		41	06		
	22.5		45	34.6		38	25	0.4702	7.23
	23.5		47	36.4		35	36		
	24.5		49	38.7		32	37	0.4650	7.51
	25.5		51	41.4		29	29		
	26.5		53	44.5		26	12	0.4597	7.81
	27.5		55	48.0		22	45		
	28.5		57	51.9		19	08	0.4543	8.12
	29.5	16	59	56.2		15	22		
	30.5	17	02	01.0		11	26	0.4489	8.44
Jan.	31.5	17	04	06.2	−5	07	20		

Encke's Comet.—The observation of Encke's comet to which we referred in our October issue, p. 546, appears to have been a pair of photographs by Wolf, at Heidelberg, which gave the position of the comet as

1916 Sept. 22 $9^h\ 6^m.6$ Gr.M.T. R.A. $22^h\ 28^m\ 39^s.0$ Decl. $-\ 7°\ 08'\ 05''$

The comet appeared as a small nebula of the 16th magnitude, with a slight condensation. The motion between two exposures agreed with the ephemeris. The comet had passed aphelion only one month earlier and it is therefore hardly proper to label this observation as made at a "return of Encke's comet."

Ephemeris of Asteroid (719) MT, Albert.—The little asteroid (719) Albert will be in opposition to the sun on January 28, 1917. As the planet is so small and as it will be at such a great distance from both the sun and earth, there will be no hope of its being photographed. I am sending ephemeris thinking that it might be of interest to astronomers to know where it will be during January, February and the first two weeks of March 1917. The ephemeris and constants are based upon the elements in the 1917 Berlin Jahrbuch.

1917 Greenwich	α			δ			log *r*	log Δ
Midnight	h	m	s	°	′	″		
Jan. 1	9	6	1	+3	56	14	0.53590	0.41655
9	8	59	35	+4	14	22	0.53932	0.41023
17	8	53	0	+4	40	40	0.54264	0.40685
25	8	45	39	+5	14	5	0.54584	0.40671
Feb. 2	8	38	14	+5	52	58	0.54892	0.41005
10	8	31	9	+6	35	19	0.55188	0.41678
18	8	24	15	+7	19	10	0.55476	0.42660
26	8	19	20	+8	2	38	0.55752	0.43910
Mar. 6	8	15	6	+8	43	57	0.56016	0.45369
14	8	12	9	+9	22	7	0.56272	0.46983

CONSTANTS.

$$
\begin{aligned}
&\qquad\qquad\qquad\qquad\quad {}^\circ \quad\ {}' \quad\ {}'' \\
x &= r\,[9.99993]\ \sin\ (275\ \ 26\ \ 43.60 + u) \\
y &= r\,[9.98928]\ \sin\ (185\ \ 12\ \ 42.00 + u) \\
z &= r\,[9.34256]\ \sin\ (190\ \ \ 3\ \ 4^{\prime}.10 + n)
\end{aligned}
$$

FRANK E. SEAGRAVE.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, October-November, 1916.

We welcome as new members of the Association this month, Messrs. Robert Barnes, "Bs," of Wheaton, Ill., and F. L. Ducharme, "D," of Arlington, Mass.

Mr. Richter's list of observations for last month was received too late for publication and is included in this month's report.

Thanks are due Mr. G. B. Lacchini for a number of blue prints for distribution and the Association is also indebted to Mr. C. B. Lindsley for plotting and publishing in POPULAR ASTRONOMY many interesting curves from the data contributed during the year.

VARIABLE STAR OBSERVATIONS October-November, 1916.

Oct. 0 = J. D. 2421137; Nov. 0 = 2421168; Dec. 0 = 2421198

J.D.	Est.	Obs.
001046		
X Androm.		
242		
1139.6	13.6	B
42.6	<12.8	Bu
59.6	<11.4	V
001032		
S Sculptoris		
1160.6	10.2	Ba
62.8	10.0	Ho
001726		
T Androm.		
1138.6	11.2	Ba
39.6	11.7	Y
40.6	11.8	Ly
40.7	11.3±	V
42.6	12.0	M
42.6	12.2	Bu
54.5	12.2	Nt
59.6	<11.5	V
60.6	<10.7	S
60.7	10.6	R
64.6	<11.5	Pi
001755		
T Cassiop.		
1138.6	10.1	M
42.6	11.3	Bu
50.6	10.4	M
55.6	10.1	Nt
60.6	<10.1	S
63.5	11.0	Pi
001838		
R Androm.		
1138	8.7	T
39.5	10.3	O
40.7	10.0	V
42.6	10.0	M
44.6	9.5	B
44.6	9.6	Bu
51.5	10.7	O
54.5	10.8	O
54.6	9.7	Hu
54.6	9.3	M
55.6	10.7	Nt
59.6	10.8	V
59.7	10.3	Mu
60.7	10.6	R
64.6	10.6	Pi
001909		
S Ceti		
1138.6	8.4	Ba
39.6	8.4	Y
42.6	8.3	Bu
51.7	8.1	M
54.5	8.2	Y
55.9	8.5	Ho
58.8	8.5	Pi

J.D.	Est.	Obs.
S Ceti		
242		
60.6	8.3	Ba
60.7	8.3	R
61.6	8.7	S
62.8	8.6	Ho
63.5	8.5	Hu
002614		
T Piscium		
1163.6	11.0	M
003179		
Y Cephei		
1138.6	11.7	Ba
42.6	<12.4	Bu
54.6	9.2	Hu
004047		
U Cassiop.		
1138.6	9.4	M
38.6	12.0	Ba
39.6	11.8	Y
42.6	11.4	Bu
51.5	12.1	Y
54.5	12.4	Nt
58.5	12.5	B
63.5	<12.5	Pi
65.5	12.6	Y
004132		
RW Androm.		
1139.5	8.6	O
41.6	8.3	M
42.5	8.7	O
42.6	8.5	Bu
51.5	9.2	O
54.6	9.3	M
55.6	9.7	Nt
64.6	9.2	Pi
70.5	9.9	O
004435		
V Androm.		
1138.6	10.2	Ba
39.5	10.4	O
42.6	11.1	M
42.6	10.6	Bu
45.6	10.7	Ly
51.5	11.0	O
54.6	11.3	Hu
55.6	11.0	Nt
64.6	12.2	Pi
004533		
RR Androm.		
1138.6	9.2	Ba
39.5	9.4	O
42.5	9.6	O
42.6	9.5	M
42.6	9.4	Bu
45.6	9.6	Ly

J.D.	Est.	Obs.
RR Androm.		
242		
51.5	9.6	O
54.6	8.8	Hu
55.6	10.0	Nt
70.5	10.6	O
004746		
RV Cassiop.		
1138.6	10.4	M
38.6	10.2	Ba
39.5	10.7	O
42.6	10.9	Bu
51.5	11.0	O
55.6	9.7	Nt
004958		
W Cassiop.		
1129.4	10.2	L
38.6	9.7	M
38.6	9.0	Ba
42.6	10.4	Bu
45.6	10.4	Ly
49.5	9.2	B
51.5	10.1	Y
010102		
Z Ceti		
1138.6	9.5	Ba
39.6	9.8	Y
54.5	10.0	Y
55.9	11.8	Ho
58.8	10.8	Pi
60.6	10.6	Ba
010940		
U Androm.		
1138.6	11.9	Ba
64.6	11.2	Pi
011208		
S Piscium		
1138.6	<13.6	Ba
59.6	<11.3	V
60.6	<13.6	Ba
011272		
S Cassiop.		
1138.6	9.6	M
39.5	9.5	O
42.6	9.2	Bu
44.5	9.0	B
44.6	9.1	Bu
54.5	9.0	O
60.7	9.2	R
63.5	8.8	Pi
012203		
R Sculptoris		
1162.8	5.7	Ho

J.D.	Est.	Obs.
012350		
RZ Persei		
242		
1139.6	12.6	Y
42.6	<12.6	Bu
65.5	12.9	Y
012502		
R Piscium		
1138.6	8.0	Ba
39.6	8.6	Y
42.6	8.0	Bu
59.7	7.5	M
60.0	7.5	Ho
61.6	7.5	S
61.6	7.8	Pi
61.6	8.0	Wpi
013238		
RU Androm.		
1142.6	<12.1	Bu
013338		
Y Androm.		
1142.6	<12.4	Bu
014958		
X Cassiop.		
1138	<11.5	T
38.6	11.5	M
42.6	<12.3	Bu
51.5	12.1	Y
54.6	12.2	Nt
58.6	11.1	B
63.5	11.3	Pi
65.5	12.2	Y
015354		
U Persei		
1138.6	7.9	Ba
39.6	8.0	Pi
39.6	7.7	Wpi
40.6	8.0	M
40.7	7.8±	V
42.6	8.0	Bu
59.6	8.1	V
59.7	8.0	Wh
59.7	7.9	Mu
63.6	8.0	Hu
015912		
S Arietis		
1142.6	<12.5	Bu
021024		
R Arietis		
1138.6	7.8	Ba
40.6	8.0	Pi
42.7	8.4	M
45.6	8.2	Bu
51.6	8.2	Pi
61.6	9.3	S
64.6	9.4	Pi
65	9.3	T
70.5	9.6	O

J.D.	Est.	Obs.
021281		
Z Cephei		
242		
1159.6	<11.5	V
021403		
o Ceti		
1133.4	6.7	L
38.6	6.3	Ba
39.7	6.2	Mu
42.6	6.0	L
42.6	6.3	Bu
45.6	6.2	Bu
52	5.7	G
53	5.5	G
53.6	5.8	Bu
54	5.4	G
54.7	4.7	E
55	5.2	G
55.9	4.0	Ho
56.7	4.6	Ba
58.8	4.5	Pi
59	5.0	G
59.6	4.3	Ba
59.7	4.4	M
59.7	4.7	Mu
61	4.7	G
61.6	4.1	Ba
61.8	4.1	Mu
62.8	4.0	Mu
62.8	4.3	E
63.5	4.2	Ph
63.6	4.0	Hu
63.6	3.8	Cr
64	4.5	G
65	4.3	G
65.7	4.2	Mu
66.7	4.0	Mu
67.6	4.7	Bu
67.7	4.2	Mu
68.7	4.0	Mu
69.7	3.8	O
021558		
S Persei		
1133.4	9.6	L
38.6	9.3	Ba
40.6	10.1	M
45.6	9.7	Bu
51.5	9.2	B
58.6	10.4	De
58.6	10.1	Pi
65.6	9.9	Bu
022101		
R Ceti		
1139.6	<12.0	Y
45.6	<12.0	Bu
60.0	10.5	Ho
022150		
RR Persei		
1139.6	8.6	Y

VARIABLE STAR OBSERVATIONS October-November, 1916—Continued.

J.D.	Est.	Obs.
023080		
RR Cephei		
242		
1159.6	<11.5	V
023133		
R Triang.		
1139	9.7	ϒ
39.6	9.3	Y
42	9.4	ϒ
44	9.5	ϒ
44.6	8.9	B
44.6	9.0	Bu
51	9.0	ϒ
54	9.0	ϒ
54.7	8.5	M
58.6	8.5	B
63	8.4	ϒ
63.6	8.0	Hu
64	8.1	ϒ
64.6	8.6	Pi
65	7.9	ϒ
65	9.4	G
65.7	9.1	Mu
66	7.6	ϒ
70.5	8.3	O
024356		
W Persei		
1129.4	9.3	L
39.6	9.7	Pi
39.6	9.4	Wpi
40.6	10.5	M
40.6	9.6	Ly
42.6	9.1	Wh
54.5	10.0	O
59.6	9.2	Bu
59.6	9.5	Wh
59.7	9.3	Mu
63.6	9.2	Hu
030514		
U Arietis		
1141.6	<12.6	Y
41.6	13.0	B
41.7	<12.8	Ba
031401		
X Ceti		
1160.0	9.2	Ho
032043		
Y Persei		
1140.6	9.7	M
41.6	9.8	B
58.7	10.2	Pi
59.6	10.4	Bu
63.6	9.5	Hu
032335		
R Persei		
1141.6	12.2	Y
54.5	11.6	Y
58.7	10.9	Pi
65.5	11.1	Y

J.D.	Est.	Obs.
033362		
U Camelop.		
242		
1139.6	8.3	Pi
39.6	8.5	Wpi
42.6	7.4	Wh
67.6	8.2	M
034625		
U Eridani		
1155.9	9.2	Ho
035124		
T Eridani		
1155.9	7.6	Ho
035915,		
V Eridani		
1155.9	8.7	Ho
041619		
T Tauri		
1141.9	10.6	M
042215		
W Tauri		
1139.7	10.3	Ba
41.7	10.0	Ba
41.9	10.6	M
54.6	10.1	Ba
54.7	10.4	M
59.6	10.0	Ba
63.7	10.3	Sp
042209		
R Tauri		
1154.7	<13.0	Nt
59.7	<10.6	V
63.6	<12.5	Y
63.7	13.5	Sp
042309		
S Tauri		
1154.7	<13.0	Nt
59.7	<10.6	V
63.6	<12.5	Y
63.7	<13.5	Sp
043065		
T Camelop.		
1141.6	12.7	Y
65.5	12.9	Y
65.9	<10.0	M
043208		
RX Tauri		
1154.7	11.0	Nt
64.6	11.0	Y
043274		
X Camelop.		
1129.4	10.8	L
38.6	11.8	Cr
39.6	12.2	Pi
39.6	12.0	Wpi

J.D.	Est.	Obs.
X Camelop.		
242		
1139.7	12.0	Ba
41.6	12.1	Ba
41.6	12.0	Y
45.6	11.9	Bu
51	<11.1	ϒ
54	<11.1	ϒ
54.5	12.8±	Y
54.7	13.0	Ba
59.7	<10.6	V
61.6	<12.3	Cr
63	<11.1	ϒ
63.6	<12.3	Pi
63.7	13.2±	Sp
64	<11.1	ϒ
65	<11.1	ϒ
65.5	12.9	Y
66	<11.1	ϒ
044617		
V Tauri		
1154.7	10.9	M
59.7	10.7	V
63.7	10.6	Sp
64.6	10.0	Y
045514		
R Leporis		
1129.0	7.5	Ho
42.6	7.1	L
55.9	7.2	Ho
58.8	8.3	Pi
60.0	7.1	Ho
63.7	8.6	M
050003		
V Orionis		
1160.0	9.2	Ho
61.9	9.2	M
050022		
T Leporis		
1129.0	10.7	Ho
55.9	10.4	Ho
58.8	11.3	Pi
60.0	10.2	Ho
62.8	11.3	E
050953		
R Aurigae		
1159.7	9.5	M
63.7	9.3	Sp
052034		
S Aurigae		
1144.6	9.1	L
59.7	9.0	M
64.7	8.9	Pi
052036		
W Aurigae		
1139.7	<12.5	Ba
59.6	<12.5	Ba
64.7	<13.4	Sp

J.D.	Est.	Obs.
052405		
S Orionis		
242		
1129.0	10.1	Ho
55.9	9.9	Ho
60.0	9.8	Ho
61.9	9.6	M
053005		
T Orionis		
1129.0	9.9	Ho
41.9	<9.7	M
42.6	10.1	L
55.8	9.8	Ho
58.8	10.0	Pi
60.0	10.1	Ho
64.7	10.7	Sp
053068		
S Camelop.		
1141.6	8.6	Y
64	8.2	ϒ
65	8.2	ϒ
65.9	9.2	M
053531		
U Aurigae		
1159.7	9.7	Ba
054319		
SU Tauri		
1139.7	9.8	Ba
41.7	9.8	Ba
44.7	9.5	Ba
59.6	9.5	Ba
60.6	9.6	Ba
61.6	9.5	Ba
62.8	9.4	E
64.9	9.5	E
054920		
U Orionis		
1144.6	9.3	L
58.8	10.2	Pi
59.7	9.6	M
62.8	9.9	E
054978		
V Camelop.		
1139.7	<12.8	Ba
41.6	<12.8	Y
41.6	<12.8	Ba
45.7	12.2	Bu
54.6	<12.8	Ba
59.6	<13.0	Ba
63.7	9.9	Sp
65.9	<10.0	M
053353		
Z Aurigae		
1151.7	9.7	M
64.7	9.7	Pi

J.D.	Est.	Obs.
060124		
S Leporis		
242		
1129.0	6.2	Ho
55.9	6.5	Ho
60.0	6.5	Ho
060450		
X Aurigae		
1139.7	9.8	Ba
64.7	8.7	Pi
060547		
SS Aurigae		
1129.4	<11.6	L
30.4	<11.6	L
39.7	<13.0	Ba
41.6	<12.4	Y
42.6	<12.4	L
44.6	<12.4	L
54.7	<12.8	Ba
59.6	<13.0	Ba
60.6	<13.0	Ba
62.8	<12.4	E
63.7	<13.5	Sp
64.6	<12.4	Y
64.7	<12.0	Pi
64.9	<12.4	E
65.6	<13.5	B
061702		
V Monoc.		
1129.0	10.5	Ho
55.9	9.0	Ho
60.0	8.5	Ho
063159		
U Lyncis		
1159.6	11.6	Ba
063558		
S Lyncis		
1159.6	9.0	Ba
64.6	9.7	Y
64.7	9.2	Sp
064932		
Nova Gemin.		
1142.6	<12.0	L
065111		
Y Monoc.		
1162.8	12.0	E
65.9	11.6	M
065208		
X Monoc.		
1129.0	7.2	Ho
42.7	7.5	L
55.9	7.6	Ho
60.0	7.8	Ho
61.9	8.0	M
065355		
R Lyncis		
1164.6	<12.4	Y
64.7	12.4	Sp

Variable Star Observations October-November, 1916—Continued.

J. D. 242	Est.	Obs.
070122a R Gemin.		
1158.7	8.1	Pi
62.8	8.2	E
65.8	8.1	M
070122b TW Gemin.		
1158.7	8.4	Pi
62.8	8.4	E
65.8	8.3	M
070122c Z Gemin.		
1162.8	12.3	E
65.8	11.0	M
070312 R Can. Min.		
1142.7	9.2	L
65.8	9.3	M
071713 V Gemin.		
1169.9	9.5	M
072708 S Can. Min.		
1140.6	8.5	Ly
41.9	8.6	M
58.8	8.3	Pi
61.9	8.4	M
62.8	8.6	E
65.8	8.3	M
072811 T Can. Min.		
1161.9	9.6	M
073508 U Can. Min		
1140.6	<11.8	Ly
42.7	11.4	L
65.8	10.2	M
073723 S Gemin.		
1158.8	<12.4	Pi
074323 T Gemin.		
1158.8	11.2	Pi
69.9	12.0	M
074922 U Gemin.		
1142.6	<11.7	L
44.7	<12.3	L
58.8	<12.3	Pi
62.8	<12.4	E
64.9	<12.4	E
65.8	<10.9	M
69.9	<11.7	M

J. D. 242	Est.	Obs.
075613 U Puppis		
1129.0	<12.2	Ho
55.9	<12.0	Ho
081112 R Cancri		
1144.7	10.8	L
69.9	11.3	M
081617 V Cancri		
1164.9	8.1	E
69.9	7.8	M
082405 RT Hydrae		
1129.0	8.1	Ho
44.6	7.9	L
55.9	7.9	Ho
083019 U Cancri		
1164.9	<11.9	E
084803 S Hydrae		
1164.9	10.0	E
69.9	10.4	M
085008 T Hydrae		
1164.9	8.8	E
69.9	9.0	M
085120 T Cancri		
1144.7	9.5	L
090151 V Urs. Maj.		
1142.6	10.3	L
55.0	9.1	Ho
65.9	10.6	M
090425 W Cancri		
1169.9	11.6	M
093178 Y Draconis		
1151.6	13.9?	Y
093934 R Leo. Min.		
1165.0	<9.4	E
69.9	10.7	M
094211 R Leonis		
1144.7	6.0	L
61.9	6.9	M
65.0	6.9	E
65.9	7.0	M
69.9	7.4	M

J. D. 242	Est.	Obs.
094622 Y Hydrae		
1160.0	6.4	Ho
095421 V Leonis		
1169.9	12.2	M
103769 R Urs. Maj.		
1138.5	7.7	Ba
40.6	7.6	Ly
41.6	7.2	M
41.7	7.6	Ba
45.7	7.4	Bu
49.6	7.4	Ly
50.6	7.5	Ba
51.5	7.8	Cr
54.6	7.6	M
54.6	7.9	Cr
55.6	7.4	Ly
59.6	7.5	Ba
63.5	7.3	Cr
64.6	7.7	M
64.6	7.3	Cr
64.6	7.5	Ly
104620 V Hydrae		
1160.0	7.5	Ho
123160 T Urs. Maj.		
1138.5	12.4	Ba
45.6	12.3	Ly
47.7	<11.4	Ba
55.6	12.4	Ly
59.5	<12.0	Ba
123459 RS Urs. Maj.		
1137.6	10.1	Bu
38.5	9.5	Ba
41.6	10.3	M
43.5	9.8	Ba
45.7	10.4	Bu
59.5	10.9	Ba
59.5	10.0	Wh
123961 S Urs. Maj.		
1137.6	8.2	Bu
38.3	8.2	L
38.5	8.2	Ba
40.6	8.3	Ly
43.5	8.2	Ba
45.7	8.2	Bu
49.5	8.3	B
49.6	8.5	Ly
54.6	8.4	M
55.6	8.7	Ly
58.5	8.9	Wh
59.5	8.6	Ba
64.6	9.0	Ly

J. D. 242	Est.	Obs.
133273 T Urs. Min.		
1139.6	<11.4	Pi
41.6	12.1	Ba
45.7	12.2	Bu
59.5	12.2	Ba
134440 R Can. Ven.		
1138.3	8.9	L
38.5	8.9	Ba
40.6	8.6	M
59.5	8.4	Ba
64.6	8.2	M
141567 U Urs. Min.		
1139.5	9.0	Pi
39.5	8.8	Wpi
41	8.7	S
41.6	8.5	Ba
45.7	8.4	Bu
49.5	8.4	B
57.5	9.0	Wh
57.6	7.8	M
59.5	8.3	Ba
64.6	8.3	M
141954 S Bootis		
1138.5	12.0	Ba
42.6	<10.6	M
54.5	<12.0	Pi
60.5	<12.3	Ba
142539 V Bootis		
1138.3	8.9	L
41.6	9.5	R
42.5	8.8	Ba
42.6	8.6	M
48.3	9.4	L
54.5	9.1	Pi
58.5	9.4	Wh
59.5	9.2	Ba
142584 R Camelop.		
1138.5	<12.7	Ba
41.6	<12.7	Y
45.6	<12.0	Ly
54.6	<11.2	Wh
54.6	12.7	Y
143227 R Bootis		
1138.3	11.7	L
38.5	11.3	Ba
144918 U Bootis		
1138.5	10.3	Ba

J. D. 242	Est.	Obs.
151714 S Serpentis		
1138.5	9.2	V
42.5	9.5	Ba
57.6	9.8	M
60.5	10.1	Ba
151731 S Cor. Bor.		
1138.5	12.9	Ba
41.6	<12.8	Ba
153378 S Urs. Min.		
1129.4	11.0	L
39.5	10.8	Pi
39.5	11.0	Wpi
39.7	10.1	R
39.7	10.7	Mu
40.6	10.7	Ly
41.6	10.4	Ba
45.7	11.2	Bu
49.5	10.3	B
49.6	11.0	Ly
55.6	11.1	Ly
57.6	11.0	M
58.5	10.6	Wh
59.5	10.6	Ba
154428 R Cor. Bor.		
1102.7	5.6	R
03.7	5.6	R
04.7	5.6	R
05.7	5.7	R
28	6.0	G
29.3	6.0	L
30	6.0	G
30.3	6.0	L
38.3	6.0	L
38.5	6.0	Ba
39.5	6.0	O
39.6	5.7	R
39.7	6.1	Mu
40.5	6.4	V
40.5	6.0	Cr
40.6	6.0	M
41.6	6.1	Ba
42.5	6.0	O
42.5	6.1	Ba
43.5	6.1	Ba
43.6	6.3	Gr
44.3	6.0	L
44.5	6.0	Ba
45.3	6.0	L
48.3	6.0	L
48.6	6.0	Ba
50	6.0	G

VARIABLE STAR OBSERVATIONS October-November, 1916—Continued.

R Cor. Bor.

J.D.	Est.	Obs.
242		
51.5	6.0	O
51.5	6.0	Cr
52	5.9	G
54.5	6.0	O
54.5	6.0	Pi
55	6.0	G
57.5	6.1	Wh
59	6.0	G
59.5	6.0	Ba
59.6	6.3	Mu
60.5	6.0	Ba
60.6	6.3	Mu
61	6.0	G
61.5	6.0	Ba
61.6	6.3	Mu
62.6	6.1	Mu
63.5	6.6	Ph
63.6	6.0	Cr

154536
X Cor. Bor.

J.D.	Est.	Obs.
1138.5	13.5	Ba

154539
V Cor. Bor.

J.D.	Est.	Obs.
1140.6	9.4	M
42.5	8.1	Ba
54.5	8.5	Pi
59.5	7.2	Ba

154615
R Serpentis

J.D.	Est.	Obs.
1138.5	12.7	Ba
45.6	<12.0	Ly

155229
Z Cor. Bor

J.D.	Est.	Obs.
1142.5	<13.0	Ba

155847
X Herculis

J.D.	Est.	Obs.
1129.4	6.2	L
30.3	6.6	L
38.3	6.3	L
39.5	6.6	O
39.7	6.5	Mu
42.5	6.5	O
46.3	6.4	L
51.5	6.4	O
54.5	6.3	O
59.5	6.4	Ba
59.6	6.5	Mu
60.6	6.4	Mu
61.6	6.4	Mu
65.6	6.4	Mu
66.6	6.2	Mu

160118
R Herculis

J.D.	Est.	Obs.
1142.5	<13.0	Ba
54.5	<11.4	V
59.5	<12.9	Ba

160210
U Serpentis

J.D.	Est.	Obs.
242		
1138.5	8.6	Ba
57.6	8.5	M
59.5	8.1	Ba

160625
RU Herculis

J.D.	Est.	Obs.
1138.5	9.5	V
39.6	9.6	M
41.6	9.2	B
42.5	9.2	Ba
54.5	10.5	O
54.5	10.5	Pi
54.5	10.7	Wpi
59.5	9.9	V
59.5	10.4	Ba
63.5	10.7	Nt

161138
W Cor. Bor.

J.D.	Est.	Obs.
1138.5	11.3	Ba
40.6	11.2	Ly
45.6	11.4	Ly
54.5	<11.5	Pi
59.5	11.9	Ba
65.5	12.1	B

162112
V Ophiuchi

J.D.	Est.	Obs.
1130.3	9.7	L

162119
U Herculis

J.D.	Est.	Obs.
1139.7	9.3	Mu
39.7	9.6	R
40.6	9.6	Ly
41.6	9.1	B
42.5	9.6	O
42.5	9.4	Ba
49.6	9.8	Ly
51.5	10.1	O
51.5	9.4	Y
51.6	9.7	Pi
55.6	10.1	Ly
59.5	10.0	Ba
59.6	9.3	Mu
63.5	9.4	Nt

162807
SS Herculis

J.D.	Est.	Obs.
1130.3	<11.8	L
38.3	11.3	L
38.5	<11.4	V
38.5	11.2	Ba
42.5	10.7	Ba
54.5	10.2	V
54.5	10.2	Pi
54.5	10.3	Wpi
59.5	10.0	Ba

163137
W Herculis

J.D.	Est.	Obs.
242		
1138.5	13.1	Ba
39.5	13.0	Y
51.6	12.8	M
59.5	11.6	Ba

163172
R Urs. Min.

J.D.	Est.	Obs.
1139.6	10.1	Wpi
39.6	10.0	Pi
39.7	9.4	R
41.6	9.5	B
41.6	10.2	M
41.6	9.5	Ba
45.7	9.8	Bu
48.6	9.5	Ba
57.5	9.7	Wh
69.5	10.1	Ba
64.6	10.3	M

163266
R Draconis

J.D.	Est.	Obs.
1138.5	11.4	Cr
40.6	11.4	Ly
41.6	11.6	M
41.6	11.3	Cr
41.6	11.4	Ba
44.6	12.8	Ba
45.6	11.2	Ly
45.7	11.5	Bu
48.6	10.9	Ba
49.6	11.2	M
51.6	10.8	Cr
54.5	10.6	O
54.6	10.5	Cr
54.6	10.5	Pi
54.6	11.2	Wpi
55.6	11.0	Ly
57.7	10.7	Wh
58.6	10.5	Cr
59.5	10.3	Ba
61.6	10.4	Cr
63.5	10.3	Cr
65.6	9.8	B
70.5	9.3	O

164055
S Draconis

J.D.	Est.	Obs.
1139.7	8.8	R
41.6	9.0	M
41.6	8.7	Ba
45.7	9.2	Bu
50.6	8.8	M
54.6	9.2	Pi
54.6	9.1	Wpi
59.5	8.8	Ba

164715
S Herculis

J.D.	Est.	Obs.
1139.6	11.1	Y
39.6	10.7	M
242		
1142.5	10.9	Ba
51.5	10.6	B
54.6	10.7	Pi
54.6	10.7	Wpi
59.5	10.2	Ba

165631
RV Herculis

J.D.	Est.	Obs.
1139.5	10.9	O
39.6	11.4	B
39.6	11.0	M
39.7	10.7	R
41.6	10.8	Ba
45.7	11.0	Bu
54.5	10.9	O
54.5	11.6	WPi
54.5	12.0	Pi
59.5	11.6	Ba
63.5	12.1	Nt

170627
RT Herculis

J.D.	Est.	Obs.
1139.6	<12.6	Y
39.6	<13.2	B
60.5	<12.8	Ba

171401
Z Ophiuchi

J.D.	Est.	Obs.
1142.5	11.8	Ba
59.5	12.0	Ba

171723
RS Herculis

J.D.	Est.	Obs.
1138.6	12.2	Hu
39.6	11.6	Y
42.5	12.1	Ba
54.6	10.5	Nt
54.6	10.5	Pi
54.6	10.5	Wpi
59.5	10.1	Ba
65.5	9.5	B

172809
RU Ophiuchi

J.D.	Est.	Obs.
1142.5	<12.6	Ba
51.6	12.2	M
53.6	12.1	Bu
54.6	<11.6	V
59.5	12.0	Ba
68.5	<12.2	V

175111
RT Ophiuchi

J.D.	Est.	Obs.
1142.5	<12.5	Ba
64.6	<11.0	V
68.5	<11.0	V

175458
T Draconis

J.D.	Est.	Obs.
1138.6	9.2	Hu
38.6	10.6	V
41.6	9.0	B
242		
41.6	9.7	M
42.6	9.7	Ba
51.6	9.0	B
54.6	10.0	V
54.6	10.1	Pi
54.6	9.8	Wpi
59.5	9.4	Ba
68.6	10.2	V

175519
RY Herculis

J.D.	Est.	Obs.
1139.5	10.8	O
39.6	11.0	Y
42.6	10.9	Ba
51.5	11.3	O
51.5	11.9	B
54.5	12.1	Pi
54.5	11.9	Wpi
59.5	12.2	Ba
63.5	13.1	Nt

180531
T Herculis

J.D.	Est.	Obs.
1139.6	13.0	Ba
39.6	9.7	M
42.6	12.7	Ba
49.6	<11.0	Bu
51.6	11.0	Pi
59.6	12.7	Ba

180565
W Draconis

J.D.	Est.	Obs.
1141.6	9.0	B
41.6	9.0	M
41.6	9.0	Ba
51.6	9.2	B
54.6	9.7	Pi
54.6	9.5	Wpi
59.6	9.3	Ba
64.6	9.9	Y

180666
X Draconis

J.D.	Est.	Obs.
1141.6	<11.5	M

180931
TV Herculis

J.D.	Est.	Obs.
1130.3	<11.7	L
38.3	<11.5	L

181103
RY Ophiuchi

J.D.	Est.	Obs.
1138.6	8.0	V
42.6	8.4	Ba
45.7	9.5	Bu
57.6	9.6	M
59.5	10.2	Ba
59.6	9.2	V
64.5	10.9	Pi
68.5	11.0	V

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181136
W Lyrae

J.D. 242	Est.	Obs.
1137.6	9.2	Bu
38.6	9.0	Gr
39.5	8.9	O
39.6	9.1	M
39.7	8.9	R
39.7	8.9	Mu
41.6	8.9	Ba
42.6	9.2	O
42.6	9.0	B
42.6	9.3	Gr
45.7	9.2	Bu
51.5	9.4	O
51.6	9.5	B
53.5	9.5	O
54.6	10.0	Wh
54.6	9.4	M
54.6	10.0	Gr
59.6	10.0	Mu
59.6	10.3	Ba
60.6	10.0	Gr
61.5	10.4	Pi
61.5	10.3	Wpi
64.5	10.0	O
65.7	10.2	Mu
67.6	<10.1	Gr

181518
Y Sagittarii

J.D. 242	Est.	Obs.
1155	5.9	G
56	5.9	G

182224
SV Herculis

J.D. 242	Est.	Obs.
1159.6	<12.7	Ba
65.6	<13.7	B

182306
T Serpentis

J.D. 242	Est.	Obs.
1038	11.6	T
39	11.6	T
42	11.3	T
44	11.5	T
45.7	<10.8	Bu
51	11.5	T
54.6	<11.5	V
59.6	<12.3	Ba
63	11.6	T
65	<11.6	T
68.5	<11.0	V

182619
U Sagittarii

J.D. 242	Est.	Obs.
1155	7.0	G
56	7.1	G

183225
RZ Herculis

J.D. 242	Est.	Obs.
1139.5	10.3	O
42.6	9.9	Ba
54.6	11.0	Pi
54.6	11.3	Wpi
59.6	11.5	Ba

183308
X Ophiuchi

J.D. 242	Est.	Obs.
1130.3	6.5	L
38.6	6.2	V
39.7	7.4	R
41.6	6.7	Ba
42.6	7.0	M
45.6	6.6	Ly
45.7	7.4	Bu
48.6	6.8	Ba
49.6	6.7	Ly
54.6	7.2	V
55	7.5	G
59.6	7.0	Ba
64.6	7.7	Pi
68.6	6.9	V

184132
RY Lyrae

J.D. 242	Est.	Obs.
1159.6	13.5	Ba

184205
R Scuti

J.D. 242	Est.	Obs.
1102.7	5.3	R
03.7	5.0	R
04.7	4.8	R
05.7	5.9	R
08	5.9	G
28	5.8	G
29.3	5.4	L
30.3	5.3	L
33.4	5.3	L
37.6	5.2	Bu
38.4	5.3	L
38.5	5.9	Ba
38.6	5.8	Pi
38.6	5.0	M
38.6	6.0	Hu
39.5	5.9	O
39.6	6.1	R
39.7	5.6	Mu
40.6	5.3	Cr
41.6	5.9	Ba
41.6	6.5	R
42.5	5.9	Ba
42.5	5.8	O
42.5	5.4	Bu
42.6	5.6	Cr
43.5	5.9	Ba
44.5	5.8	Ba
44.6	5.9	R
45.3	5.3	L
45.5	5.9	Bu
46.3	5.4	L
47.5	6.0	Bu
47.6	5.5	M
48.3	5.3	L
48.5	6.0	Bu
48.6	5.6	Ba
49.5	6.0	Bu
50	5.8	G
1150.6	5.8	Ba
51.5	5.5	Pi
51.5	5.8	O
51.5	5.7	Bu
51.6	5.8	Cr
52	5.8	G
52.5	5.7	Bu
53	5.6	G
53.5	5.8	O
54	5.6	G
54.5	5.8	O
54.6	5.7	Cr
55	5.2	G
56	5.3	G
56.6	5.7	R
57.6	5.4	Wh
59	5.2	G
59.5	5.5	Ba
59.6	5.3	Mu
60.5	5.4	Ba
60.6	5.0	R
60.6	5.0	Mu
61.5	5.5	Ba
61.6	5.5	Cr
61.6	5.1	Mu
62.6	5.2	Mu
63.5	5.2	Ph
63.6	5.2	Cr
63.6	5.1	Mu
64.5	5.6	O
65	5.0	G
65.6	5.1	Mu
66.6	5.3	Cr
66.6	5.2	Mu
70.5	5.3	O

184243
RW Lyrae

J.D. 242	Est.	Obs.
1159.6	<13.5	Ba
65.5	<13.7	B

185032
RX Lyrae

J.D. 242	Est.	Obs.
1151.6	<13.0	M
53.6	<11.9	Bu
59.6	<13.1	Ba

185634
Z Lyrae

J.D. 242	Est.	Obs.
1141.6	<13.3	Ba
59.6	<13.3	Ba

190108
R Aquilae

J.D. 242	Est.	Obs.
1130.3	7.6	L
33.4	7.9	L
38.6	8.1	M
38.6	7.4	V
41.6	7.5	Ba
42.6	7.5	B
45.7	7.8	Bu
54.6	8.1	V
58.6	8.4	Pi
59.5	7.8	Ba
68.6	8.4	V

190529
V Lyrae

J.D. 242	Est.	Obs.
1139.6	<11.4	M
59.6	<13.0	Ba

190926
X Lyrae

J.D. 242	Est.	Obs.
1139.6	9.0	M
39.7	8.8	R
41.6	8.7	Ba
59.5	9.0	Ba

190967
U Draconis

J.D. 242	Est.	Obs.
1141.6	10.5	M
49.6	11.2	M
54.6	12.1	Hu
63.6	12.1	Hu

191033
RY Sagittarii

J.D. 242	Est.	Obs.
1102.7	<10.0	R
03.7	10.4	R
04.7	<10.3	R
05.7	<10.3	R
29.3	<10.5	L
30.3	<10.5	L
31.4	<10.0	L
38.3	<10.5	L

191350
TZ Cygni

J.D. 242	Est.	Obs.
1141.6	10.2	Ba
51.6	10.6	Bu
54.6	10.9	Pi
59.6	10.7	Ba

191637
U Lyrae

J.D. 242	Est.	Obs.
1139.6	10.5	M
41.6	9.2	Ba
51.6	10.6	Bu
59.6	9.5	Ba
61.6	10.6	Pi
63.6	11.1	Nt

192508
U Aquilae

J.D. 242	Est.	Obs.
1152	6.3	G
54	6.3	G
55	6.3	G

192928
TY Cygni

J.D. 242	Est.	Obs.
1154.6	<11.2	V
60.5	<13.0	B
68.6	<11.2	V

193311
RT Aquilae

J.D. 242	Est.	Obs.
1160.5	<13.4	Ba

193449
R Cygni

J.D. 242	Est.	Obs.
1131.6	8.6	Ba
41.6	8.6	R
42	9.2	T
42.7	9.0	M
47.7	9.2	Wh
51.5	9.5	O
51.6	10.3	Bu
51.6	9.6	M
54	9.5	T
54.6	9.6	Pi
59.6	9.0	Ba
60.6	10.0	S
63	9.9	T
66	9.8	N
70.5	10.3	O

193509
RV Aquilae

J.D. 242	Est.	Obs.
1147.6	<11.2	M
51.6	12.3	Bu
60.5	11.1	Ba

193732
TT Cygni

J.D. 242	Est.	Obs.
1141.6	7.2	Ba
41.7	8.4	R
48.6	8.1	M
51.6	7.7	B
51.6	8.0	Bu
54.6	8.1	Hu
54.6	8.2	Pi
60.5	7.5	Ba

194048
RT Cygni

J.D. 242	Est.	Obs.
1141.6	8.1	Ba
41.7	8.5	R
42	8.0	T
42.7	8.5	M
47.7	7.8	Wh
51.5	7.5	O
51.6	8.0	Bu
54	7.9	T
54.6	7.0	Hu
54.6	7.8	Pi
59.6	7.4	Ba
60.6	7.7	S
63	7.9	T
70.5	7.2	O

194029
SU Cygni

J.D. 242	Est.	Obs.
1152	6.5	G
53	6.6	G
55	6.3	G
59	6.3	G
65	6.5	G

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194348
TU Cygni

J.D.	Est.	Obs.
242		
1151.6	13.4	M
51.6	<11.7	Bu
54.6	<12.1	Pi

194604
X Aquilae

1154.6	<11.3	V
55.6	13.0	B
60.5	<12.9	Ba
68.6	<11.3	V

194632
χ Cygni

1151.6	13.2	M
51.6	<12.0	Bu
65.5	12.0	B

195116
S Sagittae

1102.7	5.7	R
03.7	5.5	R
04.7	6.0	R
05.7	6.3	R
39.5	5.4	O
39.6	5.6	R
39.7	5.7	Mu
41.6	5.8	R
42.5	6.0	O
51.5	5.8	O
52	5.5	G
53	5.6	G
53.5	5.2	O
54	5.8	G
54.5	5.4	O
55	5.8	G
55.5	5.4	O
56.6	5.5	R
59	6.1	G
59.6	5.7	Mu
60.7	5.7	R
60.6	5.6	Mu
61.6	5.4	Mu
63.6	5.4	Mu
64.5	5.4	O
65	5.6	G
65.6	5.8	Mu
66.6	5.9	Mu
67.6	6.0	Mu
70.5	5.2	O

195849
Z Cygni

1138.6	8.2	V
40.7	9.2	Ly
41.6	8.0	Ba
42	9.0	ϒ
42.7	8.9	M
51.6	8.7	B
51.6	9.5	Bu
54	8.8	ϒ

Z Cygni

J.D.	Obs.	Bst.
242		
1154.6	9.2	V
54.6	9.2	Pi
59.7	9.5	Wh
60.5	9.4	Ba
60.7	10.5	Wpi
63.6	9.6	Nt
68.6	9.9	V

200212
SY Aquilae

1155.6	<12.2	B
60.5	<12.2	Ba

200357
S Cygni

1151.6	12.0	M
54.6	11.2	Pi
60.5	10.6	Ba
63.6	11.5	Nt
65.6	10.5	B

200647
SV Cygni

1141.7	9.0	R
48.6	8.0	Ba
51.6	8.3	Bu
53.7	9.0	M
54.6	9.0	Pi
59.7	9.2	Mu
60.5	8.1	Ba
60.7	9.4	Wpi
65.7	9.2	Mu

200747
RX Cygni

1159.7	7.8	Mu
65.7	7.9	Mu

200715a
S Aquilae

1138.6	9.0	M
41.7	9.4	R
42.6	9.3	B
44	9.6	ϒ
48.6	9.4	Ba
51	9.4	ϒ
51.6	9.6	B
51.6	8.6	Bu
54	9.6	ϒ
58.6	9.8	Pi
58.6	9.6	De
60.5	9.5	Ba
63	9.9	ϒ
66	9.9	ϒ

200715b
RW Aquilae

1102.7	8.8	R
03.7	8.9	R
04.7	9.0	R

RW Aquilae

J.D.	Est.	Obs.
242		
1105.7	8.9	R
38.6	8.0	M
39.6	8.9	R
41.6	8.8	R
42.6	9.3	B
44.6	9.0	R
48.6	9.4	Ba
51.6	9.3	B
51.6	8.8	Bu
56.6	9.2	R
58.6	9.2	Pi
58.6	9.1	De
60.5	9.1	Ba
60.6	9.1	R

200812
RU Aquilae

1142.6	12.6	B
51.6	13.1	B
60.5	13.1	Ba

200906
Z Aquilae

1147.6	11.2	M
51.7	12.4	Bu
60.5	12.8	Ba
62.7	<12.0	Ho
63.6	<12.0	Nt
65.6	12.0	B

200916
R Sagittae

1138.3	9.4	ϒ
38.6	10.1	M
39.3	9.4	ϒ
41.7	10.1	R
42.3	9.4	ϒ
42.6	9.7	B
44.3	9.3	ϒ
48.6	8.8	Ba
51.3	9.2	ϒ
51.6	8.9	B
54.4	9.1	ϒ
60.5	8.8	Ba
63.3	8.8	ϒ
66.4	8.9	ϒ

200938
RS Cygni

1140.7	8.6	Ly
41.7	8.7	R
45.7	8.7	Ly
48.6	8.8	M
48.6	8.2	Ba
51.7	8.5	Bu
54.6	8.8	Pi
54.6	8.0	Ba
64.7	8.9	Ly

201008
R Delphini

J.D.	Est.	Obs.
242		
1155.5	12.0	B
60.6	12.2	Ba
63.6	12.4	M

201130
SX Cygni

1141.6	12.8	Y
51.6	12.9	M
54.6	<12.9	Y
60.6	13.1	Ba
63.6	13.0	Nt

201121
RT Capricorni

1130.4	6.3	L
38.3	6.9	L
61.5	6.9	Ba
62.8	7.4	Ho

201647
U Cygni

1148.6	8.2	Ba
51.6	10.0	M
51.7	9.9	Bu
54,	<11.0	ϒ
54.6	9.6	Pi
54.7	9.7	Wh
59.7	9.7	Mu
60.6	8.0	Ba
60.7	9.7	Wpi
61.6	<9.2	S
65	9.9	G
65.7	9.3	Mu

202539
RW Cygni

1142.7	9.0	M
44.7	8.9	R
48.6	7.8	Ba
51.7	8.0	Bu
54.6	8.8	Pi
60.6	7.9	Ba

202817
Z Delphini

1138.5	13.5	Ba
38.6	<11.2	V
54.6	<11.2	V
60.6	<12.9	Ba
68.6	<11.5	V

202946
SZ Cygni

1102.7	10.0	R
03.7	9.9	R
04.7	10.3	R
05.7	9.8	R
38.5	9.1	Ba
39.6	9.8	R
39.7	9.0	Ba

SZ Cygni

J.D.	Est.	Obs.
242		
1141.6	9.3	R
41.6	8.7	Ba
42.6	9.0	Hu
44.4	10.0	R
44.5	8.8	Ba
44.6	9.1	Le
44.6	9.3	L
46.7	9.4	Le
47.7	9.5	Le
48.6	9.9	Ba
48.6	9.0	M
50.6	9.7	Ba
50.7	9.8	Le
51.6	9.4	B
51.7	9.7	Le
52.6	9.7	Le
54.6	9.0	Hu
54.6	9.4	Pi
54.7	9.0	Ba
54.8	8.9	Le
56.6	9.1	R
59.6	9.0	Le
59.6	9.2	Ba
60.6	9.3	Ba
60.6	10.0	R
60.7	9.6	Wh
61.5	9.3	Ba
62.7	9.5	Le
64.6	9.8	Le
65.7	9.8	Le

202954
ST Cygni

1138.6	9.4	Ba
51.7	9.8	Bu
54.6	10.3	Hu
54.6	10.4	Pi
60.6	10.3	Ba
63.6	10.9	Nt

203226
V Vulpeculae

1138.6	9.0	Ba
39.5	8.8	O
48.6	8.5	Ba
60.6	8.9	Ba
63.6	8.7	M

203611
Y Delphini

1155.5	11.5	B
60.6	11.1	Ba

203847
V Cygni

1142.7	10.9	M
51.6	9.3	B
60.6	9.2	Ba
63.6	9.9	Nt
67.6	10.2	M

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203816
S Delphini

J.D.	Obs.	Est.
242		
1139.6	10.1	Y
54.6	9.4	Y
63.6	9.6	M
63.6	9.0	Nt

204016
T Delphini

1139.6	12.6	Y
54.6	12.9	Y
54.6	10.6	Pi
60.6	<13.0	Ba
63.6	<13.0	Nt
65.6	13.9	B

204318
V Delphini

1155.5	<12.8	B
60.6	<12.8	Ba

204405
T Aquarii

1154.6	7.5	Hu
61.5	7.5	Pi
61.5	7.8	Wpi
61.5	7.3	Ba
62.8	7.6	Ho
67.6	8.0	M

204846
RZ Cygni

1151.6	13.0	M
54.6	11.1	V
60.6	<13.1	Ba
68.6	<11.5	V

205017
X Delphini

1160.6	<13.0	Ba

205923
R Vulpeculae

1103.7	9.0	R
38.6	6.9	Ba
38.6	8.5	Hu
39.5	9.1	O
48.6	9.6	Ba
60.6	11.2	Ba
61.7	11.1	Pi
63.6	11.3	M

210116
RS Capricorni

1103.7	8.7	R
30.4	8.3	L
38.3	8.3	L
39.7	8.2	Mu
59.6	8.0	Mu
61.5	7.7	Ba
62.8	8.0	Ho
63.6	7.9	M
63.6	8.1	Pi

210129
TW Cygni

J.D.	Est.	Obs.
242		
1161.5	<13.0	Ba
65.6	12.9	B

210382
X Cephei

1141.6	<13.2	Y

210868
T Cephei

1104.7	8.4	R
29 4	7.9	L
37.6	8.0	Bu
38.6	7.0	Ba
39.5	8.0	O
41.5	7.9	S
44.7	8.3	R
44.7	6.8	L
51.5	8.0	O
59.7	7.8	M
61.6	6.9	Ba
61.7	7.9	S

210903
RR Aquarii

1162.8	11.5	Ho

211614
X Pegasi

1138.6	9.6	Ba
51.7	9.0	Bu
58.7	9.9	Pi
59.6	10.0	Ba

211615
T Capricorni

1161.5	11.6	Ba
63.6	11.4	Pi

213244
W Cygni

1103.7	6.7	R
30.3	6.1	L
44.6	5.7	L
44.7	6.8	R
52	6.1	G
54	6.0	G
55	5.7	G

213678
S Cephei

1161.5	12.0	Ba

213753
RU Cygni

1148.6	8.6	M
58.6	8.9	Pi
58.6	8.6	De
61.6	8.5	Ba

213843
SS Cygni

J.D.	Est.	Obs.
242		
1102.7	8.6	R
03,7	8.3	R
04.7	8.8	R
05.7	8.5	R
30.3	11.4	L
38.3	10.3	T
38.5	9.9	Cr
38.5	10.2	Ba
38.6	9.9	M
38.6	9.8	V
38.6	10.6	Hu
38.6	9.8	Pi
39.3	11.3	T
39.5	10.4	O
39.6	10.4	R
39.6	10.4	M
39.6	10.5	B
39.6	11.0	Mu
39.7	10.6	Ba
40.5	10.9	Cr
40.6	10.7	M
40.6	10,6	V
40.6	10.6	Pi
40.7	10.5	Ly
41.5	<9.6	S
41.6	10.8	Ba
41.6	10.3	Cr
41.6	10.5	R
42.3	11.3	T
42.5	11.0	Ba
42.5	10.9	Cr
42.5	11.4	Bu
42.6	11.3	M
42.6	10.8	B
42.7	10.9	Wh
43.5	11.3	Ba
44.3	11.3	T
44.5	11.4	Ba
44.5	11.3	B
44.6	11.3	Le
44.6	11.2	L
44.6	11.3	Bu
45.6	11.3	Bu
45.7	11.5	Ly
47.6	11.4	Bu
48.5	11.2	B
48.6	11.2	Bu
48.6	11.1	Ba
49.5	11.3	B
49.6	11.2	Bu
50.3	11.3	T
50.6	10.9	Ba
51.3	11.5	T
51.5	10.7	O
51.5	10.7	Pi
51.5	11.3	B
51.6	11.0	M
51.6	11.0	Bu
51.6	10.8	Cr

SS Cygni

J.D.	Est.	Obs.
242		
1152.6	10.8	Bu
53.6	10.6	Bu
53.7	10.6	M
54.4	11.6	T
54.5	10.6	O
54.5	11.2	Nt
54.5	11.6	Cr
54.6	11.0	Ba
54.6	11.2	Hu
54.6	10.0	Bu
54.6	11.4	Pi
54.6	11.3	WPi
54.8	11.3	Le
55.5	11.1	Cr
55.5	11,2	B
55.5	11.2	Nt
56.6	<10.9	R
57.6	10.4	M
57.7	10.9	Wh
58.6	10.7	Cr
58.6	10.6	B
58.6	10.5	Pi
59.5	8.8	Ba
59.5	8.7	V
59.6	8.7	V
59.7	8.7	M
59.7	9.0	Le
59.8	9.5	Mu
60.5	8.7	Ba
60.5	8.2	Nt
60.6	8.1	R
60.6	8.4	S
60.7	8.6	Wh
60.7	9.5	WPi
61.5	8.8	Ba
61.6	9.2	WPi
61.6	8.6	S
61.6	8.9	Cr
62.5	8.5	Nt
62.5	8.5	Cr
62.7	9.1	Le
62.8	9.2±	E
63.3	9.3	T
63.5	9.4	V
63.5	8.9	Nt
63.5	9.0	Cr
63.5	9.2	Pi
63.6	9.1	M
63.6	9.2	Hu
63.7	9.4	Sp
64.3	9.5	T
64.4	9.4	T
64.5	9.5	O
64.6	9.4	Le
64.7	9.6	Sp
65	9.5	G
65.4	9.8	T
65.5	10.1	V
65.6	9.6	Hu

SS Cygni

J.D.	Est.	Obs.
242		
1165.6	10.0	B
65.8	10.0	Le
66.3	10.2	T
66.4	10.2	T
67.6	10.7	M
68.6	10.6	V
70.5	<10.0	O

213937
RV Cygni

1104.7	8.0	R
38.6	6.8	Ba
44.6	7.7	L
48.6	8.1	M
51.6	8.2	Bu
54.6	7.0	Hu
55	7.2	G
58.6	8.5	Pi
61.6	6.9	Ba
65	8.8	T
65.6	7.1	Hu

214024
RR Pegasi

1161.5	<13.0	Ba

214058
Mu Cephei

1154	4.0	G
55	4.0	G
65	4.2	G

215605
V Pegasi

1161.5	12.1	Ba

215934
RT Pegasi

1140.6	<11.3	V
59.5	<11.3	V
61.5	10.9	Ba

220412
T Pegasi

1139.6	13.6	B
61.5	<13.2	Ba

220613
Y Pegasi

1139.5	11.2	O
39.6	11.1	B
40.6	11.5	V
58.7	12.7	Pi
59.5	<10.9	V
61.5	12.3	Ba

220714
RS Pegasi

1139.6	12.4	B
40.6	<11.7	V
58.7	<12.5	Pi
59.5	<10.9	V
61.5	12.6	Ba

VARIABLE STAR OBSERVATIONS October-November, 1916—Continued.

221321
X Aquarii

J.D. 242	Est.	Obs.
1162.8	7.9	Ho

221722
RT Aquarii

1162.8	9.8	Ho

222439
S Lacertae

1138.6	<12.7	Ba
61.6	12.0	Ba

223841
R Lacertae

1153.7	8.9	M

225120
S Aquarii

1151.5	9.6	B
53.7	9.2	M
61.5	10.0	Ba
61.6	10.0	Pi
61.6	10.1	WPi
62.8	10.1	Ho

225657
Delta Cephei

1154	4.1	G
55	4.1	G

225914
RW Pegasi

J.D. 242	Est.	Obs.
1104.7	10.6	R
38.6	11.1	Ba
39.7	10.6	Mu
40.6	11.5	V
51.6	12.0	Bu
54.6	11.6	M
58.5	12.7	B
58.7	12.3	Pi
59.6	10.7	Mu
61.5	12.9	Ba
64.7	13.0	Sp
65	10.4	G
65.7	10.7	Mu

230110
R Pegasi

1139.7	<11.2	Mu
58.7	12.0	Pi
61.6	11.5	Ba
63.6	11.9	Nt
67.6	10.5	M

230759
V Cassiop.

1105.0	10.0	R
38.6	1.24	Ba
58.6	12.5	B
61.6	12.2	Ba
63.6	12.5	Pi
67.6	12.0	M

231425
W Pegasi

J.D. 242	Est.	Obs.
1105.7	10.2	R
38.6	11.3	Ba
40.6	10.9	V
54.6	12.0	M
59.6	<11.4	V
61.6	12.4	Ba

231508
S Pegasi

1105.7	<10.7	R
54.6	12.6	Nt
61.6	13.0	Ba

233335
ST Androm.

1105.7	8.9	R
38.6	9.3	Ba
42.6	10.0	M
44.5	10.0	B
44.6	10.4	Bu
51.6	10.6	Bu
54.6	9.6	Hu
56.6	10.5	R
61.6	10.2	Ba
64.6	10.6	Pi

233815
R Aquarii

J.D. 242	Est.	Obs.
1130.4	6.5	L
38.3	7.0	L
38.6	6.2	Ba
51.6	6.8	Bu
56.6	7.1	R
61.6	7.0	Ba
61.6	7.4	Pi
61.6	7.8	Wpi
62.8	7.2	Ho
63.6	7.0	Hu

233956
Z Cassiop.

1150.6	12.0	M
54.6	12.2	Nt
61.6	12.4	Ba
63.6	12.4	Pi

235209
V Ceti

1138.6	11.3	Ba
53.7	11.0	M
61.6	12.5	Ba
63.6	12.7	Nt

235350
R Cassiop.

J.D. 242	Est.	Obs.
1138	<11.5	T
44.5	12.0	B
44.6	12.5	Bu
54.6	12.3	Nt
61.6	12.0	Ba

235525
Z Pegasi

1138.6	10.8	Ba
39.5	10.5	O
51.5	10.5	O
54.5	10.4	O
54.6	10.3	M
58.7	10.4	Pi
59.6	10.1	V
61.6	9.8	Ba
70.5	9.8	O

235939
SV Androm.

1138.6	12.4	Ba
42.6	<11.6	M
61.6	<12.7	Ba
64.6	<12.3	Pi

No. of observations 1544; No. of stars observed 242; No. of observers 28.

Mr. Bancroft calls attention to an error in the chart of the Variable *021403* o Ceti (naked eye view) in the possession of many of our observers. A line drawn from the 4.5 magnitude star through the 4.0 magnitude star terminates at a star designated 4.9 magnitude on some charts. This star is η Eridani, a star of the 4.0 magnitude. Members who are using this defective chart are requested to correct this error.

The planet Neptune is now close to the field of the Variable 083019 U Cancri. Observers are notified of the fact to prevent needless disappointment in the announcement of a Nova.

The following calculated dates of maxima are cited from the "Companion to the Observatory."

Dec. 4	203847	V Cygni	Dec. 12	*151822*	RS Librae
5	163266	R Draconis	15	*233815*	R Aquarii
8	164055	S Draconis	28	210868	T Cephei
8	123307	R Virginis	30	230110	R Pegasi
11	180531	T Herculis	31	142584	X Camelop.

For the convenience of observers the following monthly Julian dates for the year 1917 are cited:

Jan. 0	2421229	May 0	2421349	Sept. 0	2421472
Feb. 0	1260	June 0	1380	Oct. 0	1502
Mar. 0	1288	July 0	1410	Nov. 0	1533
Apr. 0	1319	Aug. 0	1441	Dec. 0	1563

We are indebted to Mr. Wm. J. Delmhorst of Jersey City, N. J., for several observations contributed to this report which are designated by the abbreviation "De."

The Secretary regrets that owing to absence from home this winter he will have to give up his secretarial duties temporarily. During his absence Mr. John J. Crane, Shawme Farm, Sandwich, Mass., has kindly consented to act as Secretary, and lists due February 1st, March 1st, and April 1st should be sent to Mr. Crane. Acknowledgements of the receipt of lists will be dispensed with to lighten the work, and members can best assist Mr. Crane by sending in their lists promptly on the first day of the said months.

The following members contributed to this report: Messrs. Bancroft, Bouton, Burbeck, Crane, Eaton, Gray, Gregory, Hoge, Hunter, Lacchini, Leonard, Lindsley, McAteer, Mundt, Newberry, Nolte, Olcott, Phillips, D. B. Pickering, S. W. Pickering, Richter, Spinney, Vrooman, Whitehorn, Yendell, Miss Swartz, and Miss Young.

William Tyler Olcott,
Norwich, Conn., November 10, 1916. Corresponding Secretary.

SU Tauri.—A letter from Mr. H. C. Bancroft, Jr., of West Collingswood, N. J. calls attention to the decreasing light of the variable star SU Tauri, 054319. The variations of this star, like those of R Cor. Bor., 154428, are very irregular and peculiar. The variation is rapid, and has been confirmed here. The star should be watched carefully.

Harvard College Observatory, Bulletin 617,
Cambridge, Mass., U. S. A., November 17, 1916.

COMMUNICATIONS.

A Day of Exceptional Meteorological Interest.—The afternoon of July 2, 1916, was cloudy over the lower part of the Bay of Panamá and thereby developed a remarkable scene about half past five o'clock, as seen from the deck of the Pacific mail steamer San Juan.

Two great masses of cloud, dark leaden in hue, were in the west; and in them could occasionally be seen bright flashes of lightning running vertically. At the right—or north—of the middle of these clouds was a strip 3° to 4° wide, and 12° to 14° long, of sunshine on a white background; and at the summit of the northern cloud was a thin stripe of silver lining surmounted by a band of irregular shape on which were displayed broad spectrum effects; not arcs of rainbows, but rainbow colors in two or three broad masses. The phenomenon was a wonderful one and unique in my experience. It was visible for five or six minutes, gradually changing its shapes and finally shifting to the southern cloud, and disappearing through being covered up by the advance of a fresh mass of cloud.

That evening Polaris was visible at an altitude, by eye-measurement, of 7½°. By consulting a good atlas one may see how little this varied from the fact.

I made also an estimate of R Muscae, 68° south declination.

Edward Gray.

A Rare Volume.—You and your readers may be interested to know that a gentleman and friend of mine residing in this city who makes frequent trips to New England was fortunate enough during a recent visit in Boston to locate and procure a copy of the first issued "Annals of the Astronomical Observatory of Harvard College," being Volume 1, part 1 and 2, published in 1856, which is now very scarce and difficult to obtain.

It is a "presentation copy" and on a blank leaf in front appear these words, evidently in the handwriting of Professor Wm. C. Bond, who was the first director of Harvard Observatory: "To Charles P. Curtis, Esq., from the Observatory of Harvard College. W. C. Bond, Director." Professor Bond was the father of the famous G. P. Bond who in 1850 discovered the faint third or inner ring of Saturn, commonly known as the "dusky ring." The volume is bound in brown cloth, and though somewhat worn from age it is complete and fairly well preserved considering the date of its publication.

On the title page is a wood cut of the original Observatory building, above which are these words: "Printed from funds resulting from the will of Josiah Quincy, Jun., who died in April, 1775, leaving a name inseparably connected with the history of the American Revolution." The volume contains a "History and Description of the Astronomical Observatory of Harvard College," by Professor Bond, the director, together with a number of diagrams and illustrations, and gives a great amount of information concerning the Observatory and its associates which is interesting to read and well worth preserving.

The volume contains a lengthy appendix with the reports of the President, Director and Visiting Committee of the Observatory, some of them dating back to the year 1845, and there are also a number of letters from American and foreign astronomers giving some valuable information pertaining to the heavens. Being the first annual publication issued by the Harvard Observatory it has long been out of print and is now an interesting relic of astronomical literature which would be a valuable addition to the library of any observatory or private student of the science.

The owner of the rare volume, not being specially interested in astronomy, offers it for sale, his price being seven dollars, which is very low for such a valuable treasure, and he has placed it in the hands of the writer who will send it post paid on receipt of the price. ARTHUR K. BARTLETT.

Battle Creek, Mich., November 11, 1916.

GENERAL NOTES.

Dr. J. L. E. Dreyer has resigned his office as director of the Armagh Observatory, a position which he has held since 1882.

Maurycy Rudzki, director of the Cracow Observatory since 1902, has died at the age of 54 years.

Professor A. S. Donner, director of the Observatory of Helsingfors, has presented to the university of which he was formerly rector, the sum of £8,000, to ensure the continuance and completion of the "Catalogue photografique du Ciel, Zone de Helsingfors," begun under his direction in 1890. Hitherto the work has been paid for, partly by the university, partly by Professor Donner out of his private means. The sum now allotted by him is intended to cover all expenses for twelve years, when, at its present rate of progress, the task should be finished. *Science*, November 17, 1916.

Dr. Cleveland Abbe, the distinguished American meteorologist, died on October 28th, at his home in Washington, D. C., in the seventy-eighth year of his age.

Professor S. A. Mitchell, director of the Leander McCormick Observatory of the University of Virginia, has been appointed by Columbia University special Ernest Kempton Adams research fellow for a period of five years. This award comes as an extension of the regular Adams fellowship held by Professor Mitchell for the years 1914-16. The research undertaken was the determination of the parallaxes of the fixed stars by photography with the 26-inch McCormick refractor. Already the distances of one hundred stars have been determined.

Professor O. Backlund, director of the Pulkovo Observatory, died on August 29.

Dr. Percival Lowell, director and owner of the Lowell Observatory at Flagstaff, Arizona, died of apoplexy on November 12. He had during the previous month been on an extended lecture tour, giving astronomical lectures at the State College of Washington, University of Washington, Reed College, Oregon Agricultural College, University of Oregon, Leland Stanford Junior University and the University of California.

From the daily newspapers we learn that Dr. Lowell was buried on "Mars Hill" not far from the observatory in which he made so many of those wonderful drawings of the features seen on the surface of the planet Mars. According to the terms of his will the Lowell Observatory is to be supported out of a fund to be held in trust by William Lowell Putnam, the astronomer's brother-in-law.

The American Association of Variable Star Observers held its fourth annual meeting at the Harvard College Observatory on November 18, 1916.

Parallax of Barnard's Star with Large Proper Motion.—A letter received at this Observatory from Professor Frank Schlesinger, Director of the Allegheny Observatory, states that:—

"Measures of Photographs secured here with the Thaw Telescope yield a preliminary parallax of half a second of arc for the rapidly moving star in Ophiuchus, recently discovered by Barnard. The probable error of this result is about three one-hundredths of a second of arc." EDWARD C. PICKERING, Director.

Harvard College Observatory, Bulletin 616,
Cambridge, Mass., U. S. A., November 10, 1916.

Daylight Saving.—The plan of daylight saving in the summer time by setting the clocks forward an hour appears to have worked well in England. Even the astronomers have not seriously objected. Professor H. H. Turner in the October issue of *The Observatory* wrote in favor of the plan. Mr. C. Chree presents the other side of the question in the November number of the same journal.

Barnard's Star of Large Proper Motion.—A letter received at this Observatory from Professor Henry Norris Russell, Director of the Princeton University Observatory, contains the following preliminary values of the parallax of the star of large proper motion in Ophiuchus which have been determined by him from micrometric observations communicated by Professor Barnard.

From the differences of the distances of stars a and k, a solution in which the proper motion is eliminated in the usual manner, gives a parallax of $0''.69 \pm 0''.06$.

Measures of positives made from the plates of 1894 and 1904, when compared with the measures of 1916, give a proper motion of $10''.38$ toward 355°.8. Assuming this proper motion, the distance measures of the stars a, c, and k give parallaxes of 0″.85, 0″.53 and 0″.66, and the measures of position angle a mean parallax of 0″.75. The mean of these determinations is 0″.70 ± 0″.05.

The absolute magnitude of this star on Kapteyn's scale is 13.6, and its real brightness is less than one three-thousandths that of the sun, making it the faintest star so far known.

Harvard College Observatory, Bulletin 617,
Cambridge, Mass., U. S. A., November 17, 1916.

Professor Keeler's Photographs of Nebulae.—A limited number of copies of Volume VIII, Publications of the Lick Observatory (Professor Keeler's photographs of nebulae and clusters made with the Crossley reflecting telescope), are available for distribution to astronomers, students of astronomy, observatories, university and college libraries, and other libraries of high character, upon payment of the mailing charges. The volume wrapped for mailing weighs five pounds and will cost sixty cents to send to points east of Chicago, to Canada, and to such foreign countries as have parcel post interchange with the United States. The rates for points west of Chicago may be ascertained from the local postmaster. Money order or stamps for transportation charges should accompany the request.

W. W. Campbell.
Director Lick Observatory.

False Stereoscopic Effects.—It seems to be necessary to accept with caution the evidences of motion of stars based upon the stereoscopic comparison of two photographs. The following is taken from the notes "From an Oxford Notebook" in *The Observatory* for November, 1916:

"In turning over these pages of the *C. R.*, one's attention is naturally caught by the claims of M. Comas Sola to have found conspicuous proper-motions by the stereoscopic method (*C. R.*, 1915 Aug. 9) near M 11. Professor Barnard took the pains to examine the region on two plates having an interval of 22 years (*C. R.*, 1915 Oct. 4), whereas M. Sola's plates had only three years' interval; but could find no evidence of large proper-motions, a negative conclusion for which he was prepared by much previous work with micrometers both visual and photographic. But M. Sola was not convinced of any illusion or mistake, for a few months later he announces very sensible proper-motions, indicating a rotation, in the Orion nebula (1916 March 20). Now many of us have had experience of false stereoscopic effects: for instance, Dr. Metcalf, when studying theology at Oxford a dozen years ago, used our stereo-comparator, in his 'leisure' moments, with some diligence, and ultimately found a star showing a distinct stereoscopic effect which we all verified on his announcement. We proceeded to *measure* the two images with respect to surrounding stars, and could find no sensible difference! It was a considerable disappointment, but an educational one. There was no doubt about the stereoscopic effect, nor any obvious explanation of it except the usual one, but the usual one was negatived by the micrometer. It seems probable that if M. Sola would submit his plates to the test of measurement, he would also find the stereoscopic effect to be due to some obscure cause, and not to a sensible displacement."

The Eclipsing Binary RX Herculis.—In the Laws Observatory Bulletin No. 25 is given an extensive study, by Robert H. Baker and Edith E. Cummings, of the observations of the variable star RX Herculis ($\alpha = 18^h\ 26^m.0$, $\delta = +12°\ 32'$). This star is of the Algol type and its light changes may therefore be explained as the result of successive eclipses of one by the other of a pair of stars which whirl around each other in a period of 1.78 days. The star is not double visually, but its spectrum at the proper times has double lines, so that there is no question as to its duplicity. The range of brightness is from magnitude 7.2 to magnitude 7.9. Figure 1 shows a comparison of the theoretical light curve with observed magnitudes. The secondary minimum is not quite so deep as the primary, showing that the stars are unequal in brightness. The calculations show, however, that the two stars have very nearly the same diameter, 1.6 times the diameter of the sun. The mass of the brighter component is 0.96 and of the fainter component 0.91 that of the sun. Their densities are respectively 0.27 and 0.23 that of the sun or about one-sixteenth the density of water.

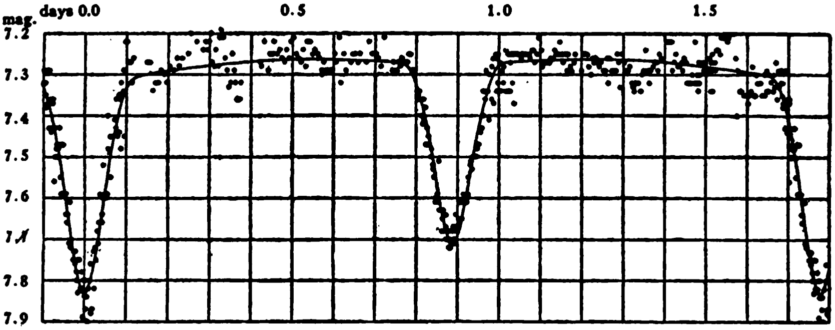

FIGURE 1. OBSERVED MAGNITUDES AND THEORETICAL LIGHT CURVE OF RX HERCULIS

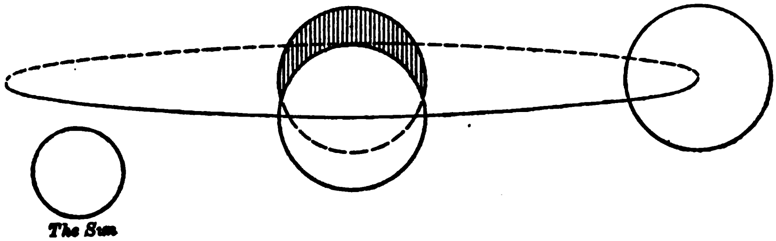

FIGURE 2. THE SYSTEM OF RX HERCULIS COMPARED WITH THE SUN, AT SECONDARY MINIMUM AND AT GREATEST ELONGATION.

Figure 2 gives the relative sizes of the stars and the sun and the aspects which they would present to us if we could see the actual stars when at conjunction and when widest apart. The orbits of the two stars are circular and their inclination (from perpendicular to the line of sight) is 83°.9. The distance between the centers of the two stars is about five times the radius of either star, or 5,280,000 kilometers. At conjunction 70 per cent of the disk of one star is eclipsed by the other. The semi-duration of eclipse is 2^h 53^m.

The range of radial velocity indicated by the spectrograms is over 200 kilometers per second. When the brighter component is approaching us the velocity is about —124 kilometers, and when receding, about + 84 kilometers. The fainter component has a slightly greater range of velocity. The center of gravity of the two is approaching us, the radial velocity of the system being — 19.5 kilometers.

The Velocity of Vega.—A correspondent sends us a clipping from "The Pathfinder" of August 19, 1916, in which is given the statement that "Vega is leaving us at the rate of some 9,000,000 miles a second, according to the revelations of the spectroscope." The writer evidently made a big mistake in his calculations. According to the Lick Observatory measures the radial velocity of Vega is —13.8 kilometers or —8.6 miles per second, i.e. it is approaching us (instead of leaving us) at the rate of a little less than nine miles each second. As, however, the solar system is going toward Vega about 12 miles per second, the star is really moving in the opposite direction between three and four miles a second. Vega also has a cross-motion of approximately seven miles a second, so that its real motion through space is very near eight miles a second. It would take Vega nearly two weeks to move 9,000,000 miles.

Ancient Astronomy in Egypt.—A pamphlet recently issued by "School of Antiquity", Point Loma, California, entitled "Ancient Astronomy in Egypt and its Significance", by Frederick J. Dick, professor of mathematics and astronomy, contains some very remarkable statements,—very important if they can be verified. For example:—

"The Assyrians have not only preserved the memorials of seven and twenty myriads (270,000) of years, as Hipparchus says they have, but likewise of the whole planetary sidereal periods and periods of the seven rulers of the world."

"The Hindus are said, on pretty good authority, to have had the complete records of thirty-three precessional circuits, this amounting to over 850,000 years."

"The Egyptians have on their zodiacs irrefutable proofs of records having embraced about 87,000 years."

"Pomponius Mela wrote that the Egyptians preserved in written records the memory of the fact that the stars had completed four revolutions, or more than 100,000 years, during their history. Pliny wrote that Epigenes assigned 720,000 years to the astronomical observations of the Chaldeans."

This is going a great deal farther back than students of the early history of astronomy have hitherto dared to suggest as possible.

The American Astronomical Society will hold its twentieth meeting in connection with the seventieth meeting of the American Association for the Advancement of Science in New York City from December 26 to December 30, 1916. This is the first of the greater quadrennial meetings of the A. A. A. S., and an effort is being made to have all of the affiliated societies in attendance. The address of the retiring president of the A. A. A. S., Professor W. W. Campbell, will be of special interest to the members of the American Astronomical Society. The Manhattan hotel, Forty-second and Madison streets, has been selected as headquarters for the American Astronomical Society. The session for the presentation of papers will be held in Room 304, Fayerweather Hall, Columbia University. The detailed program for the meetings of the Society has not yet been announced. It is planned to arrange the meetings of the Society at such times as to avoid conflicts with the general meetings of the Association. Sessions for papers will probably be held at ten o'clock on Wednesday, Thursday and Friday mornings and on Friday afternoon. On Thursday afternoon there will be a joint session of the Society with The American Mathematical Society, The Mathematical Association of America and Section A of the Association. The features of this meeting will be addresses by Professor E. W. Brown, retiring president of The Mathematical Society, and by Professor A. O. Leuschner, retiring vice-president of Section A. A large attendance is expected.

3 2044 077 079 19

3 2044 077 079 192